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Conference Proceeding

THE 10th ANNUAL INTERNATIONAL SEMINAR ON TRENDS IN SCIENCE AND SCIENCE EDUCATION

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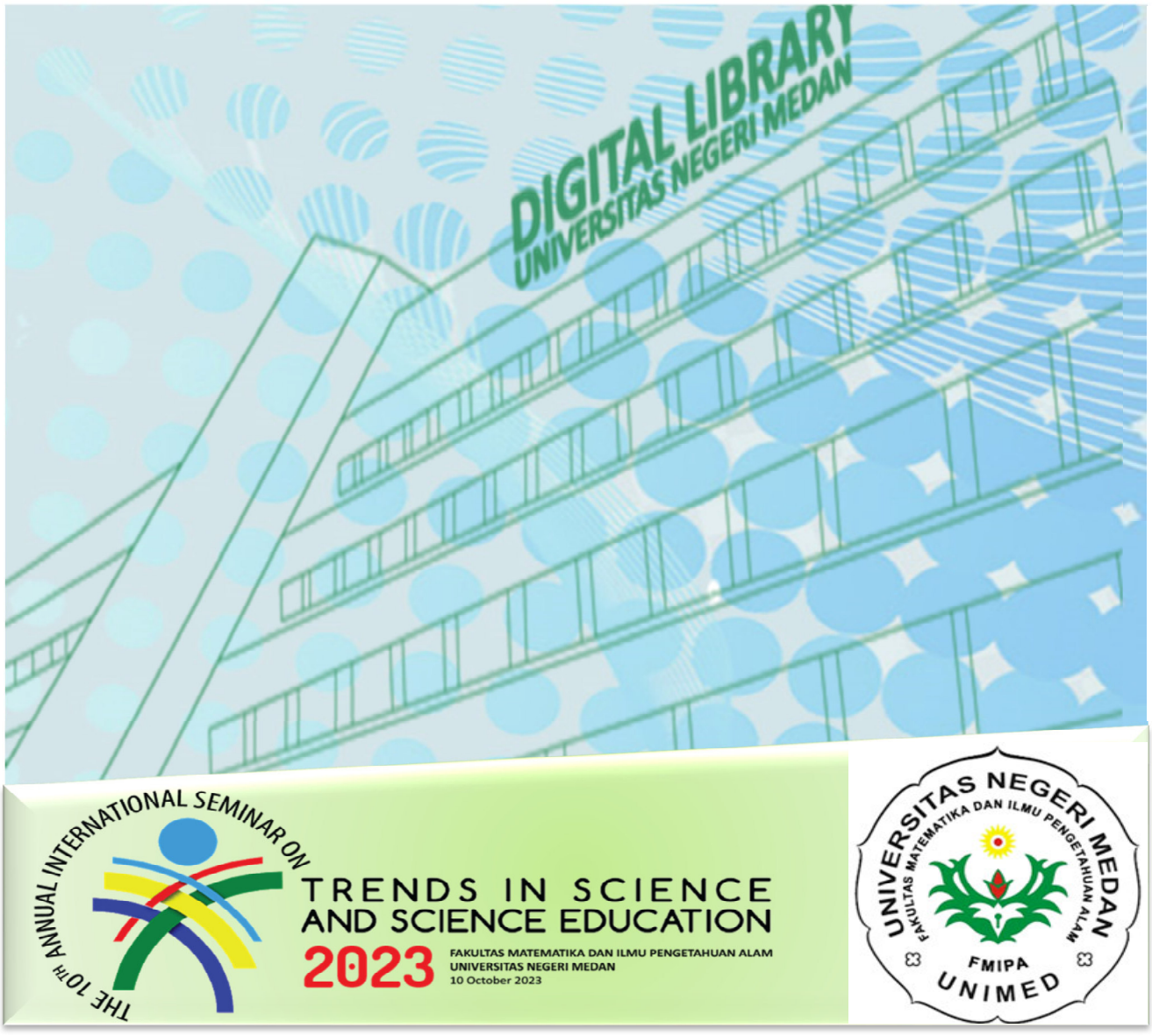
Medan, Indonesia • *October 10th, 2023*

Editors • Fauziyah Harahap, Jamalum Purba, Ani Sutiani, Marini Damanik, Moondra Zubir, Said Iskandar Al Idrus



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Preface: Proceedings of the 10th Annual International Seminar on Trends in Science and Science Education (AISTSSE) 2023

This is the 10th meeting since it was first held in 2014 and the fourth virtual meeting due to the COVID-19 pandemic. This year seminar is focusing on how big the contribution of research to the development of technology in industry field, and we make the theme of this exciting forum is 'FUTURE MATHEMATICS, NATURAL SCIENCES, AND EDUCATION TRENDS TO ACHIEVE SUSTAINABLE DEVELOPMENT GOALS FOR ADDRESSING THE SOCIETY 5.0 CHALLENGE.", which embraces six main topics, including:

1. Fundamental and applied research in mathematics including basic mathematics, applied mathematics and statistic
2. Fundamental and applied research in physics including theoretical physics and computation, geophysics, material science and technology
3. Fundamental and applied research in biology including fundamental biology, applied biology and biotechnology
4. Fundamental and applied research in chemistry including instrumentation, basic chemistry, and applied chemistry
5. Science education
6. Computer science

For this year conference, we invited four plenary speakers with solid expertise from different countries and regions are

1. Prof. Dr. Syawal Gultom, M.Pd – Universitas Negeri Medan, Indonesia,
2. Prof. Teresa J. Kennedy, Ph.D. (STEM Education) - University of Texas at Tyler, USA.,
3. Prof. Dr. Yatimah Alias (Chemistry) Universiti Malaya, Malaysia
4. Sirilak Chumkiew, Ph.D. (Biology), Suranaree University of Technology, Thailand
5. Prof. TS Dr. Ahmad Kadri Junoh (Mathematics) – Universiti Malaysia Perlis
6. Prof. Dr. Usmeldi, M.Pd. (Physics Education) – Universitas Negeri Padang.

We also invited five invited speakers with different expertise field to initiate the presentation in parallel sessions are :

1. Prof. Dr. Suyono, M.Pd. (Chemical Education), Universitas Negeri Surabaya,
2. Prof. Dr. Mangasi Alion Marpaung, M.Si. (Physics), Universitas Negeri Jakarta, Endah
3. Retnowati, Ph.D. (Mathematics Education), Universitas Negeri Yogyakarta,
4. Hendra Susanto, Ph.D. (Biology), Universitas Negeri Malang

Therefore, on behave of the committee, I would like to take this opportunity to extend my appreciation to the Rector of State University of Medan, The Dean of the Faculty of Mathematics and Natural Sciences, the invited plenary speakers, paper presenters, delegates and guests, and participants that have supported us to host this conference. In addition, my sincere thanks go to organizing team and student volunteers for un-tiring efforts to make this conference as a memorable one. We hope that you all enjoy this seminar and get the latest information about the progress of science and science education research and its application in the industrial field. Thank you very much for your attention, Wabilahi Taufiq Walhidayah, Assalamualaikum Warrahmatullahi Wabarakatuh.

Dr. techn. Marini Damanik
Committee Chairman

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Proceedings of the 10th Annual International Seminar on Trends In Science and Science Education (AISTSSE) 2023

Table of Contents

NO	AUTHORS / *TITLE*	PAGE
1	Raden Arjuna Surbakti, Ashar Hasairin,Tri Harsono *The development of teaching materials based on problem based learning models to improve critical thinking abilities and scientific attitudes in the semester II of class X SMA/MA*	1
2	Salwa Rezeqi, Wasis Wuyung Wisnu Brata,Amrizal Amrizal, Putri May Vandayani Banjarnahor *Digital literacy skills of biology students through ICT project assignment*	13
3	Ely Djulia / *Multiple representation – based earning media about human organ System for secondary biology classroom*	25
4	Widya Arwita, Aswarina Nasution, Onggal Sihite *Profiling creativity of undergraduates student in biology education through bullet journaling*	30
5	Cicik Suriani, Wina Dyah Puspita Sari, Herkules Abdullah, Fitri Afifah Nasution *Development of student worksheets based on development of student worksheets based on case methods and time-based project in plant morphology courses*	38
6	Widia Ningsihhalim Simatupang, Widya Arwita, Sri Dewi, Edi Purwanto *Online Diagnostic Assesment in Support of Differentiated Learning*	45
7	Ashar Hasairin, Lazuardi Lazuardi, Puji Prastowo, Miftahul Jannah, Eko Prasetya, Wira Risa Lina Simanjuntak *Phytochemical screening and antibacterial activity test of lichen extract Usnea barbata against Bacillus cereus & Escherichia coli*	51
8	Rindy Ruth Napitu, Hendro Pranoto, Melva Silitonga *Decoction of sikkam bark (Bischofia javanica) on blood glucose levels and pancreatic histopathology in alloxan-induced white rats (Rattus norvegicus)*	59
9	*Syahmi Edi, Friends Silaban, Muhammad Iqbal* *The effect of growth regulatoring substances iba (indole butyric acid) and naa (naphtalene acetat acid) on the growth of andaliman (zanthoxylum acanthopodium dc.) cuttings bud for plant cultivation the quality of export*	66
10	Khairiza Lubis, Lydia Ruth Hasianna Manullang, Ferosalina Natasia Saragih, Debi Rausana Nasution, Agung Setia Batubara, Elida Hafni Siregar, Mufti Sudibyo *Species characterization of three tor species (family cyprinidae) based on morphometric analysis*	80
11	Marsal Rispandi, Novita Sari Harahap, Nimrot Manalu, Nurhamida Sari Siregar *Ginkgo biloba extract and exercise on brain-derived neurotrophic factor (bdnf) levels*	88
12	Ahmad Shafwan S Pulungan, Mhd Yusuf Nasution, Dina Handayani, Ade Yesi Yuliana *Analysis of the secondary metabolite content of the ethanol extract of Asystasi gangetica leaves*	92
13	Mhd Yusuf Nasution, Marlinda Nilan Sari Rangkuti, Dina Handayani, Tessa Togatorop *Phytochemical analysis of ethanol extract of urena lobata leaves*	99
14	Melva Silitonga, Hudson Sidabutar, Hendro Pranoto, Adriana Yulinda Lumban Gaol, Dendi Janius Siregar, Valmer Gading M. Siregar, Chitra Marpaung, Clara Anastasya Hasugian	105

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https://doi.org/10.2478/9788367405782-toc

	Effect of ethanol extract of leaf of Biden spilosa (L) on the hematological profile of alcohol-greated white rats	
15	Fauziyah Harahap, Figertana Figertana, Tengku Gilang Pradana, Nurul Huda Panggabean, Chairunas Adha Putra, Nusyirwan Nusyirwan, Nursamsu Nursamsu *Development of tissue culture textbook based on scientific literacy in growth regulatory and production of metabolic secondary*	114
16	Mufti Sudibyo, Khairiza Lubis, Dwi Wahyuni Nurwihastuti, Ayu Liani Veronika *Mangrove sediment carbon stock on the east coast of North Sumatra*	134
17	Erlintan Sinaga, Melva Silitonga, Uswatun Hasanah, Feimmy Ruth Pratiwi Sipahutar *Saurauia vulcani korth against hepato-renal carcinoma integrated spleen damage in rats induce rhodamine b : in vivo and in silico*	145
18	Isnaini Nurwahyuni, Riyanto Sinaga, Manihar Situmorang, Riris Mandaoni Siahaan *Screening of secondary metabolite compounds of medicinal raw materials in Sumatrana Frankincense (Styrax benzoin) cultures*	152
19	Eko Prasetya, Wulan Sari Laksa, Tri Harsono, Lazuardi Lazuardi *Macroinvertebrate diversity as a bioindicator of the water quality in the Belumai River, Deli Serdang Regency, North Sumatra*	160
20	Martina Asiati Napitupulu, Rahmad H. Gultom, Eni Wati, Khairunnisa Nasution, Susi Juliana Simanjuntak, Desta Ratu Melysa *Immunomodulatory activity of ocimum americanum l. Leaves against free-range chicken infected with eimeria tenella with cecum structure parameters*	168
21	Nora Susanti, Jamalum Purba, Muhammad Nizam, Maria Aprina Br Surbakti, Ruth Maria Meylisa Br Hutapea *Antibacterial Activity Test Against Ethanol Extract of Frankincense Sap (Styrax benzoin)*	175
22	Ahmad Nasir Pulungan, Nurfajriani Nurfajriani, Agus Kembaren, Junifa Layla Sihombing, Muhammad Irvan Hasibuan, Rahayu Rahayu, Saud Salomo, Nurul Hidayah, Feby Erna Br Ginting *Upgrading Bio-Oil Through Esterification-HDO Process: Optimization Of Temperature And Mass Ratio Of Fe-Co Mixed Metal Oxide Catalyst Supported By Mordenite*	182
23	Destria Roza, Sya Sya Azzaythounah, Nora Susanti, Yuni Warti, Tita Juwita Ningsih *Synthesis of Quercetin-Chitosan (Qt-Cs) Nanoparticles as Flavonoids Derivatives of Coffee Leaves Parasite (Loranthus parasiticus (L.) Merr) Isolates*	191
24	Herlinawati Herlinawati, Junifa Layla Sihombing, Agus Kembaren, Lisnawaty Simatupang, Efi Febiola Siburian *Adsorption of Fe Metal Analysis in Wastewater Using Nano Chitosan Coated Corn Cobs Adsorbents from Green Mussel Shells*	201
25	Ratna Sari Dewi, Hafni Indriati Nst, Minda Syafina Syafei, Surya Julius Sembiring, Ela Riana Br Ginting, Putri Karmina, Abdul Mutholib, Anni Anggraeni, Husein H. Bahti, Ari Hardianto, Muhammad Yusuf *Simulation Study of Dibutylditiocarbamate (DBDTC) Ligand Molecular Dynamics for Extraction of Rare Earth Elements*	208
26	Elfrida Ginting, Hasri Tri Maya Saragih, Zuhairiah Nasution, Elfrida Siregar, Ecclesia Siregar, Nadrah Nasution *Conversion of Durian (Durio zibethinus) Seed Waste into Bioethanol*	217
27	Jasmidi Jasmidi, Moondra Zubir, Rini Selly, Putri Faradilla, Siti Rahmah *Optimization of Fe-Cu activated carbon derived oil palm empty fruit bunches in reducing free fatty acid value and peroxide value of crude palm oil (CPO)*	223
28	Marham Sitorus, Retno Dwi Suyanti, Iis Siti Jahro, Suria Bersinar Siahaan *Transformation of cinnamic acid in frankincense (STYRAX paraleoncomud PERK) into ethyl cinnamate*	228
29	Marini Damanik, Nora Susanti, Ida Duma Riris, Jihan Afstria Rinanda, Nurul Ramadhaniyah	234

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https://doi.org/10.2478/9788367405782-toc

	Analysis of free fatty acid and water content in tinuktuk during the storage period at room temperature	
30	Murniaty Simorangkir, Saronom Silaban, Simson Tarigan, Yesica Marcelina Romauli Sinaga *Effect of fixation type on color quality of cotton thread with natural dyes of local plants jabi jabi (Ficus retusa L) leaf extracts*	239
31	Ida Duma Riris, Tita Juwita Ningsih, Marini Damanik *The effect of a mixture extract of cinnamon (Cinnamomum burmanii) bark, ginger (Zingiber officinale), and lemongrass (Cymbopogon citratus), on alloxan-induced male Rattus novergicus SGPT, SGOT levels*	246
32	Tita Juwitaningsih, Zuhairiah Nasution, Destria Roza, Eddiyanto Eddiyanto *Antibacterial and antioxidant activity of 5,6-dehydrokawaine compound from Alpinia malaccensis seeds*	254
33	Suyono Suyono, Utiya Aazizah, Bertha Yonata, Antina Delhita *Student Support Program in Formulating a Research Framework*	261
34	Ani Sutiani, Iis Siti Jahro, Jamalum Purba, Dewi Syafriani, Ricky Andi Syahputra *Improving student's critical thinking abilities through developing teaching materials using the PBL STEM model based on chemical literacy*	274
35	Anna Juniar, Siti Rahmah , Tua Paimaon Tambunan, Pravil M Tambunan *Development of interactive teaching materials based on inquiry based learning (IBL) models based on the outcome-based education (OBE) curriculum in analytical chemistry learning*	281
36	Ayi Darmana, Haqqi Annazili Nasution, Mutiara Agustina Nst, Putri Faradilla *The correlation between chemistry learning outcomes and independent character in the 2022 class student of faculty of mathematics and natural sciences (FMIPA) UNIMED*	288
37	Bajoka Nainggolan, Anna Juniar Ambarita, Ramlan Silaban *Development of project-based interactive e-modules in accordance with the IQF integrated curriculum concept in learning organic chemical reactions to improve student chemistry learning outcomes*	295
38	Dewi Syafriani, Ayi Darmana, Feri Andi Syuhada, Dwy Puspita Sari, Susilawati Amdayani, Putri Faradilla *Analysis of the validity and practicality of IBM SPSS statistics teaching materials based on Project-Based Learning (PjBL) on the t-test topic*	311
39	Ratu Evina Dibyantini, Susilawati Amdayani, Muhammad Isa Siregar, Dewi Syafriani *Development of STEM-PjBL integrated teaching materials on organic compound materials to improve student science literacy*	320
40	Jamalum Purba, Freddy Tua Musa Panggabean, Ani Sutiani, Ratu Evina Dibyantini, Risdo Gultom *Improving students' creative thinking abilities through developing general chemistry teaching materials based on the pjbl stem model*	331
41	Manihar Situmorang, Abil Mansyur, Winsyahputra Ritonga, Suci Pujiastuti, Maya Oktara, Hasianna Nopina Situmorang *Evaluation of Academic Collaboration Activities Supporting the Achievement of University Performance Indicators*	338
42	Gulmah Sugiharti, Haqqi Annazili Nasution, Mutiara Agustina Nasution, Muhammad Isa Siregar *The effect of web media on increasing student learning outcomes in material analysis instruments*	346
43	Marudut Sinaga, Asep Wahyu Nugraha, Ani Sutiani *Implementing of prior knowledge evaluation and 5E learning cycle in stoichiometry*	352

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https://doi.org/10.2478/9788367405782-toc

	learning design to improve students' critical thinking skills	
44	Asrin Lubis, Arnah Ritonga, Andrea Arifsyah Nasution *A theoretical review towards the use of simulator in mathematics learning at university*	360
45	Erlinawaty Simanjuntak, Hanna D.M. Hutabarat, Lasker P. Sinaga *Rewang culture-based learning in cooperative learning models with OBE approach*	368
46	Glory Indira Diana Purba, Yasifati Hia, Katrina Samosir *Development of interactive teaching materials based on problem-based learning model to improve students' mathematical reasoning ability*	373
47	Michael Christian Simanullang, Marojahan Panjaitan, Nurliani Manurung *Development of higher-order thinking skills oriented scaffolding in the course of complex variable functions*	382
48	Denny Haris, Chairunisah, Edi Syahputra *Research-Based Learning Model Using Local Wisdom of Rewang in Mathematics Education Research*	390
49	Mukhni Mukhni, Khairani Khairani, Mirna Mirna *Learning style: student learning achievements of analysis real course by online learning*	396
50	Mukhtar Mukhtar, Muliawan Firdaus, Muhammad Badzlan Darari *The Development of Mathematics Discourse-Based Learning to Improve Teacher Students' Procedural and Conceptual Understanding of Multivariable Calculus*	403
51	Sahat Saragih, Zul Amry, Humuntal Banjarnahor, Dichi Akbar Wahyudi *Implementation of Algebra Structure Teaching Materials Assisted With Concept Map Media Through Student-Centered Learning To Improve Proof Ability*	414
52	Dian Armanto, Sri Lestari Manurung, Susiana Susiana, Jeki Chrisman Situmeang, Sujoko Waluyo *Students' Weaknesses in Learning Fractions Using Newman's Errors Category*	423
53	Tri Andri Hutapea, Rahmatsyah Rahmatsyah, Irwansyah Siregar *Enhancement of problem-solving Skills Student's Completed Creativities Programs Development*	435
54	Katrina Samosir, Humuntal Banjarnahor, Michael Christian Simanullang *Development of a digital number theory book supported by explainer videos to enhance students' critical thinking skills*	441
55	Nurliani Manurung, Wingston Leonard Sihombing, Mariani Mariani, Michael Christian Simanullang *Development of Integral Calculus Book Based on Problem-Based Learning Model Oriented to HOTS*	447
56	Marojahan Panjaitan, Michael Christian Simanullang, Mariani Mariani *Development of a digital integral calculus book assisted by animation videos to enhance students' critical thinking skills*	453
57	Didi Febrian, Putri Harliana, Mansur As *Career Prediction of Undergraduate Alumni Using Fuzzy Logic*	458
58	Hanna D.M. Hutabarat, Tri Andri Hutapea, Nurul Ain Farhana *The Principal Component Analysis of Regional Wealth Factors of Indonesia*	467
59	Hamidah Nasution, Mulyono Mulyono, Ruth Salisa Br Sihaloho, Faiz Ahyaningsih, Rizka Anisa Mingka *Solutions of nonlinear differential equations system on infectious disease using perturbation homotopy method*	473
60	Izwita Dewi, Ade Andriani, Siti Ramadhani Putri Zulham, Syahir Sasri Habibi *Analysis of Mathematical Critical Thinking Abilities of Middle School Students Studying With a Brain-Based Learning Approach*	480
61	Lasker P. Sinaga, Dinda Kartika, Nurul Ain Farhana *Stability and sensitivity analysis of SEIQR model on dynamics of SARS-CoV-2 with*	487

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https://doi.org/10.2478/9788367405782-toc

	international in-out mobility in Indonesia	
62	Mulyono Mulyono, Hamidah Nasution, Putri Maulidina Fadila, Silvya Ajeng Saraski *Generalization of Cramer's rule*	500
63	Sudianto Manullang, Marlina Setia Sinaga, Pardomuan N.J.M. Sinambela, Novan Setyadi, Jesika Casadae Wanda Barus, Millenia Nainggolan Millenia Nainggolan *Survival analysis of cox proportional hazard regression model in coronary heart patients by using exact method*	508
64	Susiana Susiana, Chairunisah Chairunisah, Nice Rejoice Refisis *Descriptive analysis of the cost of living in urban areas in Indonesia*	515
65	Faridawaty Marpaung, Arnita Arnita, Sri Dewi *Analysis of public transport route medan city using A* algorithm and google maps API for route optimization based on web*	523
66	SL Manurung, Glory I.D Purba, Putri Harliana *Development of Digital Teaching Materials Based on Higher Order Thinking Skills (Hots) to Improve Students' Creative Thinking*	530
67	Debi Yandra Niska, Nice Rejoice Refisis, Putri Maulidina Fadilah *Decision support system (DSS) for assessment of tracer study results to improve the quality of graduates*	539
68	Insan Taufik, Kana Saputra S, Adidtya Perdana *Development Of Higher Education Tridharma Recapitulation Information System For Lecturers Of Computer Science Department Universitas Negeri Medan*	547
69	Kana Saputra S, Debi Yandra Niska, Insan Taufik, Mhd Hidayat, Fajar Muharram Mohammed Hafizh Al-Areef *Comparison of Convolutional Neural Network Architecture for Identification of Hypertensive Retinopathy Using Retina Fundus Images*	552
70	Mansur As, Fauziyah Harahap, Didi Febrian, Sitti Subaedah, Mario Köppen *Metaverse approach as educational tool in online learning systems*	560
71	Hermawan Syahputra, Martina Restuati, Dedy Kiswanto, Aqila Aqila, Taufik Abdullah *Classification of hair disease using cnn with VGG-16 architecture*	571
72	Zulfahmi Indra, Syahril Efendi, Muhammad Zarlis, Herman Mawengkang *Optimizing Product Distribution Processes in Online Business Using Data-Driven Models*	579
73	Deo Demonta Panggabean, Jurubahasa Sinuraya, Rajo Hasim Lubis, Febriani Putri Keren Goni, Siska Dewi Titania Situmorang, Alieffia Dzilbira *The effect of inquiry-based module with sets (science, environment, technology and society) integrated into dynamic fluid material*	587
74	Irfandi Irfandi, Alkhafi Maas Siregar, Festiyed Festiyed, Skunda Diliarosta *The development of ethnoscience in schools: a bibliometric analysis with a detailed future insight review*	596
75	Irham Ramadhani, Purwanto Purwanto, Ridwan Abdullah Sani, Yanthy Leonita Perdana Simanjuntak, Lihardo Rotua Sinaga, Afrida Khairani Rangkuti *Validity of digital learning media for information technology and data literacy courses to optimize hybrid learning in the physics department*	611
76	Rajo Hasim Lubis, Deo Demonta Panggabean, Amelia Sitompul, Nova Srydevi Simanjorang, Ira Santi Siagian, Nanda Julfa Rezeki *Smart Module for General Physics Practicum Based on the Case Method and Team-Based Project*	615
77	Ratna Tanjung, Teguh Febri Sudarma, Festiyed Festiyed *Mobile Learning and Malay Culture: An Examination of Android-Based Learning Media Validation and Effectiveness*	621
78	Sabani Sabani, Dewi Wulandari, Sahyar Sahyar *Optimizing Learning With the Case Method and Team Based Project in the Subject*	627

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https://doi.org/10.2478/9788367405782-toc

	of Measurenment and Assessment of Learning Physics	
79	Wawan Bunawan, Pardomuan Sitompul, Irham Ramadhani *The case method as an assessment a practical approach to wave superposition learning*	635
80	Dewi Wulandari, Muhammad Aswin Rangkuti, Yul Ifda Tanjung, Irham Ramadhani *Description of standing wave module based on stem*	641
81	Yeni Megalina, Rugaya Rugaya, Juniar Hutahaean *Development of hybrid learning design assisted by LMS sipda in modern physics course*	647
82	Ahmad Andi Solahuddin, Winsyahputra Ritonga, Budiman Nasution, Habibi Azka Nasution *Edge detection for cracks in building concrete structures using the canny algorithm*	655
83	Budiman Nasution, Habibi Azka Nasution, Eviyona Laurenta Br Barus, Silvia Dona Sari, Reni Riani, Dina Oktaviana Silaban, Rahayu Agustina, Nova Syahfitri Siregar *Comparative study of concrete mix materials on the response of multi-storey building structures using the finite element method*	662
84	Rahmatsyah Rahmatsyah, Putri Zainab Nasution, Aisyah Safira, Abigail Concilia Brigitta Marpaung, Bella Salsadilla Br Ginting, Rita Juliani, Syarifuddin Syarifuddin, Agung Setia Batubara *Composition of fishermen's catch using gill nets in Bagan Serdang, Deli Serdang Regency, North Sumatra Province, Indonesia*	670
85	Aristo Hardinata, Ely Djulia, Mariati Purnama Simanjuntak *Development of a science literacy assessment book for junior high school students: the feasibility based on classical test analysis and expert judgment*	675
86	Lastama Sinaga, Widia Ningsih, Pintor Simamora, Artha Christina Sinaga, Rizky Agassy Sihombing *Developing a stem-based interactive e-module to improve tpack of prospective science teachers through lesson study*	683
87	Sahat Siagian, Ali Fikri Hasibuan, Tri Andri Hutapea *Creating a model for developing creativity programs for Medan State University students*	691
88	Sarah Fazilla, Nurdin Bukit, Sriadhi Sriadhi *Development of the tpack-based project-based learning (pjbl) model for prospective elementary school teacher students' professional competence*	701
89	Septian Prawijaya, Imelda Free Unita Manurung, Laurensia Masri Perangin-Angin, Yusri Effendi, Karenina Sitanggang, Mariana Mariana, Siti Nurhalizah *Using chatbot ai for learning basic physics and chemistry concept in elementary school teacher education*	710
90	Wina Dyah Puspita Sari, Cicik Suriani, Aswarina Nasution, Ermy Veronica Sitompul *Ethnoscience study of sinyar- nyar fish and sale fish typical batak angkola culinary in south tapanuli regency*	717

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The development of teaching materials based on problem based learning models to improve critical thinking abilities and scientific attitudes in the semester II of class X SMA/MA

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Abstract. *Based on the problems in this research, the material that is poorly understood and often misunderstood is the material about environmental change. Apart from that, the teaching materials used in the learning process are textbooks provided by the government. Therefore, one effort that can be made is to develop teaching materials that can support student knowledge and designed to enable them to think at a higher level in solving problems, so that researchers take the initiative to develop PBL-based teaching materials. This research aims to determine the design for developing PBL-based teaching materials to improve critical thinking skills, scientific attitudes, and to determine the feasibility of PBL-based teaching material products to improve critical thinking skills according to expert assessments. This type of research is research and development that refers to the ADDIE model. The steps taken in research and development are design analysis and development. This research does not use implementation and evaluation. The instruments used in this research were a media expert validation sheet and a material substance validation sheet with a four category scale. The results of the research show that: (1) the design for developing PBL-based teaching materials to improve critical thinking skills is in the feasible category, (2) the feasibility of PBL-based teaching materials to improve critical thinking skills as assessed by media design is in the feasible category with an index of 3, 85 and material substance experts are also in the appropriate category with an index of 3.80. Thus, it can be concluded that PBL-based teaching materials to improve critical thinking skills can be used in the learning process in SMA/MA.*

Keywords: ADDIE, PBL, environmental change, critical thinking, scientific attitude

Introduction

Biology is the science that studies everything about living beings and all activities related to these living beings. Biology is not just a mastery, a collection of knowledge in the form of concepts, principles, and discoveries, but also a knowledge that is factual or real so that in learning biology, a person learns to recognize and understand themselves and others. The learning process emphasizes the provision of direct experience to develop student's thinking.

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In general, schools only use textbooks as a guide for students and teachers. Textbooks published by publishers who have been referred by the government to develop teaching materials are feasible but still need to be developed along with the material learning strategies [1]. However, the existence of this textbook is not enough to make it easier for students to understand the material taught. Teachers have an important role in improving the quality of learning in the classroom. One of the efforts to improve the quality of learning is to obtain quality learning resources, which can be achieved through quality teaching materials as well [2]. Quality teaching materials must be able to deliver material in accordance with the curriculum, follow the development of Science and technology (science and technology), and bridge learning so that the competencies set can be achieved, especially in biology learning [3].

Based on the reality that occurs in schools, in learning biology also found that there is still less readiness of students to follow the lessons of biology, management of lessons with information and discussion methods generally still tend to lead to the provision of information so that learning is still dominated by teachers. Questions posed by teachers can rarely be answered by students or only answered by certain students. Most of the questions asked by the teacher are answered by the teacher himself. In learning, students 'initial ideas are relatively poorly explored and considered in learning, students tend to be passive, students' motivation for independent learning is lacking, and knowledge sharing between students is less facilitated [4]. Biology subjects conducted so far tend to only pay attention to the number of subjects and the allocation of time available, by pursuing the achievement of the curriculum without considering some of the important things that have been outlined by the curriculum. [5]. In biology, students should be expected to understand the concept and its application in life. In addition, students are also expected to develop their thinking power to solve problems which is one of the 21st century learning skills [6].

Based on the results of the Program for International Student Assessment (PISA) survey in 2006, it was found that students in Indonesia were in position 50 out of 57 countries with an average score of 391 out of an international average score of 500, while in 2009, Indonesia was in position 61 out of 67 countries with an average score of 371 out of an international average score of 500. Another Survey conducted by Trends in International Mathematics and Science Study (TIMSS) in 2007, the results showed that the ability of first-level secondary school students in Indonesia is ranked 35 out of 49 countries with an average achievement score of 427 out of an average score of 500 international [7]. This proves that Indonesia is still in a low rank and requires a more effective learning process by using quality teaching materials [8].

Based on the results of interviews and observations in senior high school Al-Amjad Medan obtained the following data, (1) the learning process in senior high school Al-Amjad Medan only use the package book and LKPD (worksheet for student), (2) the package book used is less interesting and has not been equipped with activities that understand students, (3) LKPD used does not contain about evaluation in the form of multiple choice and description, (4) Character Education conducted by class teachers has not been integrated directly in the learning process, (5) students in high school are still showing many attitudes that require attention, such as undisciplined in terms of entering class, lack of responsibility for teacher duties, passivity in the learning process, and dishonesty during the evaluation process, 6) students find it difficult to understand biology learning materials, especially those related to environmental change.

In addition, the data value of students in Class X is still relatively low and has not met the minimum completeness criteria (KKM). The low results of Biology study in terms of the Daily test scores of students who obtained scores above the new KKM (≥70) 38.46% (10 students out of 26 students) and who have not reached the KKM (≥70) 61.53% (16 students out of 26

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students). In addition to the Daily test scores, the low cognitive learning outcomes are also shown from the mid-semester test scores obtained above the value of the new KKM (≥70) 34.61% (9 students out of 26 students) and who have not reached the KKM (≥70) is 65.38 % (17 students out of 26 students).

From the above problems, the researcher designed a study with the title "Development Of Teaching Materials Based On Problem Based Learning Model To Improve Critical Thinking Skills And Scientific Attitudes In Even Semesters Of Class X Senior High School", so that this study can be a reference and reference for teachers in conducting a quality learning process, especially in Biology subjects.

Methods

The type of research used is Research and Development Research and Development (R&D). This research refers to the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). However, this research only reached the development stage. In the Analysis stage, at this stage the researcher conducts an analysis of the teaching materials used and makes observations regarding what teaching materials are needed at school, then the researcher conducts the research stage, namely at the Design stage, at this stage a design is carried out regarding the teaching materials to be made and then the Development stage, namely development of teaching materials, validation tests by experts, and teachers. Data collection in this study was carried out using a validation test analysis questionnaire by experts. The questionnaire was prepared based on the student teaching material assessment instruments issued by the BSNP. The questionnaire was made using a 4-level Likert scale, with criteria 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. The results of the data obtained will be calculated using the formula:

$$P = \frac{\sum q}{\sum r}$$

Where:

P = Score obtained, in this case is the percentage component of the standard assessment of innovative teaching materials according to BSNP.

$\sum q$ = Number of concepts marked with (√) in innovative biology teaching materials for SMA/MA class X even semester.

$\sum r$ = The number of concepts in the innovative chemistry teaching materials for SMA/MA class X even semester.

This research was carried out in January of the even semester of the 2022/2023 academic year at Al-Amjad Private High School Medan, North Sumatra province. In the five-month time interval, it includes analyzing, designing, developing, implementing products, and evaluating. The population in this study is all Class X students at Al-Amjad private high school, consisting of 5 classes consisting of 3 science classes and 2 social science classes for the 2022/2023 academic year. The selection of samples in this study using purposive sampling technique is the determination of research samples based on the consideration of researchers who consider the desired elements of researchers have been in the sample members taken and suggestions from teachers in the field of biology at SMA Privat Al-Amjad. Research samples as much as one class, namely Class X Science 1 as an experimental class.

Then the results are interpreted using a rating scale, to indicate the level of feasibility of teaching materials with the following assessment criteria.

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Table 1. Criteria for the validity of the average value analysis

Average	Interpretation
3.26 - 4.00	Valid and does not need to be revised (feasible)
2.51 – 3.25	Valid enough and does not need to be revised (decent enough)
1.76 – 2.50	Invalid, some of the contents of teaching materials need to be revised (less feasible)
1.00 – 1.75	Invalid and needs to be totally revised (not feasible)

(a) (b)

Figure 1. Experiment class (a), and control class (b) in research.

Cite all figures in the text in consecutive order. The word "Figure" should be spelled out if it is the first word of the sentence and abbreviated as "Fig." elsewhere in the text. Place the figures as close as possible to their first mention in the text at the top or bottom of the page with the figure caption positioned below, all centered. Figures must be inserted in the text and may not follow the Reference section.

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Results and Discussion

Analysis Phase

The result of the development carried out by this researcher is to produce teaching materials based on problem based learning. This research and development was carried out using the development procedure according to Sugiyono which was carried out from stage 1 to stage 7. The initial stage was carried out, namely the researcher collected information relating to the constraints that existed in the school. The researcher also interviewed all the biology teachers and students and collected books, materials and journals related to the module. The results of the interviews also concluded that the biology learning process carried out by the teacher in the classroom generally still uses biology learning, still uses direct learning and tends to use the lecture method, giving examples on the blackboard, asking questions and continuing with assignments. The process of learning chemistry in the classroom tends to be theoretical, memorizing or factual knowledge only and pays little attention to students' critical thinking skills. According to K-13 learning, teachers are required to innovate in learning. Where one of the innovative learning models in the 2013 curriculum is problem-based learning or called Problem Based Learning this model is an approach that presents authentic problems so that it can stimulate students to learn.

The next step in this study was to analyze two books of high school biology class X, coded A and B. The researchers analyzed the books using the BSNP instrument. The following presents the results of the percentage analysis of the feasibility of textbooks.

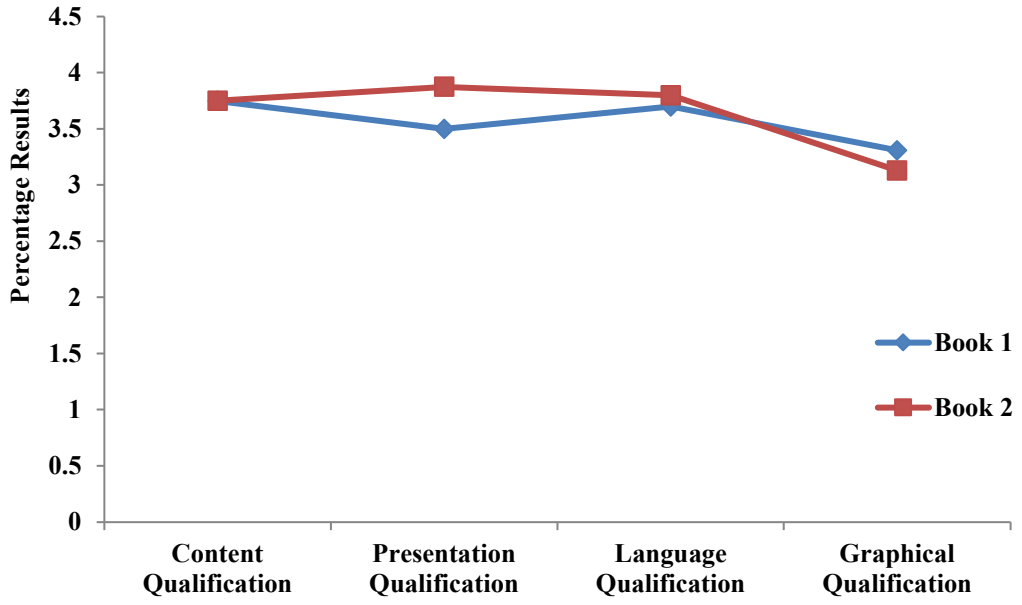

Figure 2. The Percentage Results of Feasibility Analysis of Two Biology Textbooks

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Table 2. Content Feasibility Aspect Analysis

No	Content Eligibility Aspects	Analysis Results	Development Solutions
1	Material Coverage	The material presented in the material has not focused on indicators and learning objectives to be achieved.	Include indicators and learning objectives based on the basic competencies of class X chemistry material so that the material presented can achieve the learning objectives.
2	Material Accuracy	The accuracy of the concepts presented is in accordance with the field of knowledge, does not lead to many interpretations, and the examples presented are in accordance with reality but have not been able to increase user understanding.	Add life facts that cannot support understanding of the concept to materials or examples to increase user understanding.
3	up to date	The material presented is in accordance with current developments in chemistry, but there are still supporting materials for achieving learning objectives that have not been conveyed.	Include up to date materials that support learning objectives and update examples and exercises to make them more interesting and innovative.
4	Growing Student Productive Character	It is enough to increase student activity to participate in learning activities, but the media is less able to increase student activity in finding answers because the exercise is only in the form of a few questions.	Modify the media by adding interactive exercises to make it more interesting and foster student activity in learning.
5	Stimulate Curiosity	Descriptions, examples and exercises are not able to stimulate students to think further because the content of the media has not been able to involve students directly in learning.	Modifying media content that can involve students directly in using media and get feedback from what they have done as well as new innovations that can stimulate students' curiosity regarding chemistry learning material.

Based on the results of the analysis of the four aspects of the assessment, namely content feasibility, language feasibility, presentation feasibility and graphic feasibility of the teaching materials that are often used, namely text textbooks. So it can be said that the teaching materials used are appropriate, but the textbook needs to have a textbook companion that is innovated.

Design Phase

After the analysis phase was carried out, the researcher continued the next stage, namely the design stage. At this stage the researcher collects sources or references related to the even semester class X material and designs the initial teaching materials based on Problem Based Learning. At this stage, the format selection and initial product design are carried out in accordance with the opinion. The material that will be included in this teaching material is in accordance with the learning objectives and achievement indicators that have been determined, the researcher also collects images, animations, websites that will later be visited as additional references.. The design made can be seen in Figure 3.

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Figure 3. The Initial Design of Teaching Materials

Development Phase

In this development phase, the product to be developed is made, namely teaching materials based on Problem Based Learning. On research, states that the teaching materials to be used must have valid criteria from expert validators so that they are ready for use. Based on previous research at the development stage, teaching materials must be valid before being used. There are also activities carried out, namely compiling material, apperception, questions so that they are systematic and in accordance with predetermined indicators. After everything is finished, combine all the teaching materials that have been prepared using the Canva and Ms.Word applications. The problem-based teaching materials that will be developed follow the syntax of problem-based learning, which begins with problem orientation, organizing students, guiding investigations developing and presenting work and finally analyzing and evaluating the problem-solving process. The syntax of problem-based learning is incorporated into the developed teaching materials. Material validation was carried out by five Chemistry Education lecturers at Medan State University and three teachers using a feasibility questionnaire instrument based on the BSNP. The aspects tested to see the feasibility of a media consist of content eligibility, language eligibility, presentation feasibility and graphic feasibility. The results of the feasibility test of material experts and teachers on Problem Based Learning-based teaching materials can be seen in Figure 4.

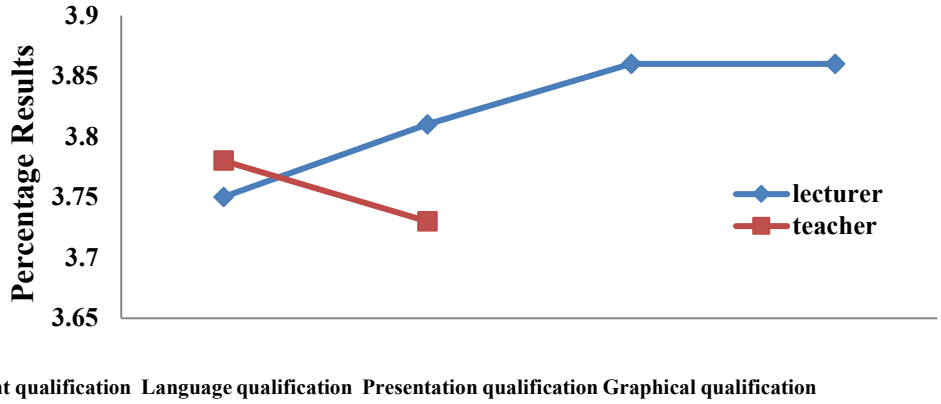

Figure 4. The Percentage Results of Feasibility Test of Problem-Based Teaching Materials Based Learning by Material Expert Validator

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Based on the validation results of problem-based teaching materials by the material expert validator. data obtained average percentage of 3.86 (biology lecturer) and 3.73 (biology teacher). From the results of the validation above, it can be seen that the problem-based teaching materials developed have fulfilled the validity criteria, namely they are very suitable for use without revision. After being validated and given input by expert validators, problem-based teaching materials are obtained that are suitable for use without revision. The following shows the problem-based teaching materials that have been developed.

Figure 5. The Display of Teaching Materials / Modules Based on Problem-Based Learning

The feasibility test was carried out to determine the percentage of eligibility of the developed teaching materials. The Problem Based Learning-based biology teaching materials developed were validated by 8 expert validators (6 chemistry lecturers and 2 biology teacher in Al Amjad School) using the BSNP questionnaire. Qualitative analysis techniques were obtained from assessments on a questionnaire containing standard BSNP teaching materials (Appendix 3). Teaching materials that have been developed are validated and analyzed using descriptive analysis.

Content Eligibility

The results of the analysis of Problem Based Learning-based teaching materials that have been developed based on the feasibility aspect of the content by lecturers and teachers as expert validators can be seen in Figure 6.

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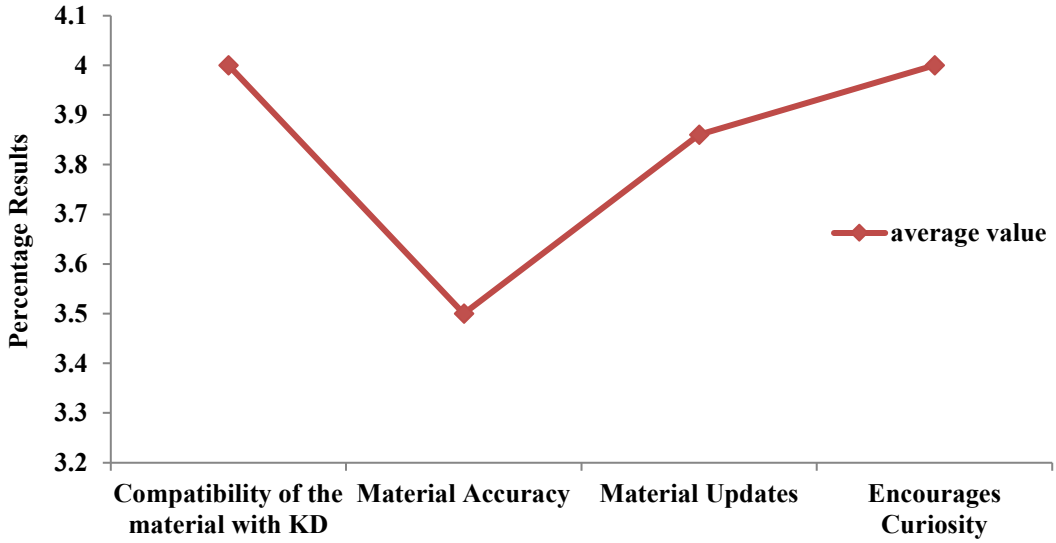

Figure 6. The Graphic of The Feasibility Analysis of The Contents of The Developed Teaching Materials

The content feasibility aspect is in accordance with the modified BSNP standard, there are 4 indicators. Based on the results of the analysis, the feasibility value of the content on the aspect of suitability of the material with Basic Competency (KD) has the highest score of 4.00 in the valid category without revision, and encourages curiosity to get a score of 4.00. This shows that the content of the material in teaching materials developed has covered all the material contained in Basic Competency (KD). Other indicators, namely material harmony, material up-to-date and encouraging curiosity, have an average value of 3.50; 3.86 and 4.00; all have valid categories without the need for revision.

Language Eligibility

The results of the analysis of Problem Based Learning-based teaching materials that have been developed based on aspects of language feasibility by Lecturers and Teachers as expert validators can be seen in Figure 7. Aspects of the feasibility of the language used include four indicators, namely aspects according to the development of students, clarity of sentences and levels of readability, aspects of writing the contents of teaching materials and aspects of language use, terms and symbols. The highest aspect is the clarity of sentences and the level of readability, namely 3.67, which is in the valid category without the need for revision. This shows that the Problem Based Learning-based teaching materials that have been developed have good sentence clarity and legibility and are expected to make it easier for students to easily understand the contents of the teaching materials. The results of the analysis for other aspects, namely the aspect of writing the contents of teaching materials and aspects of using language, have an average value of 3.67; 3.86 . These three aspects are included in the valid category without the need for revision.

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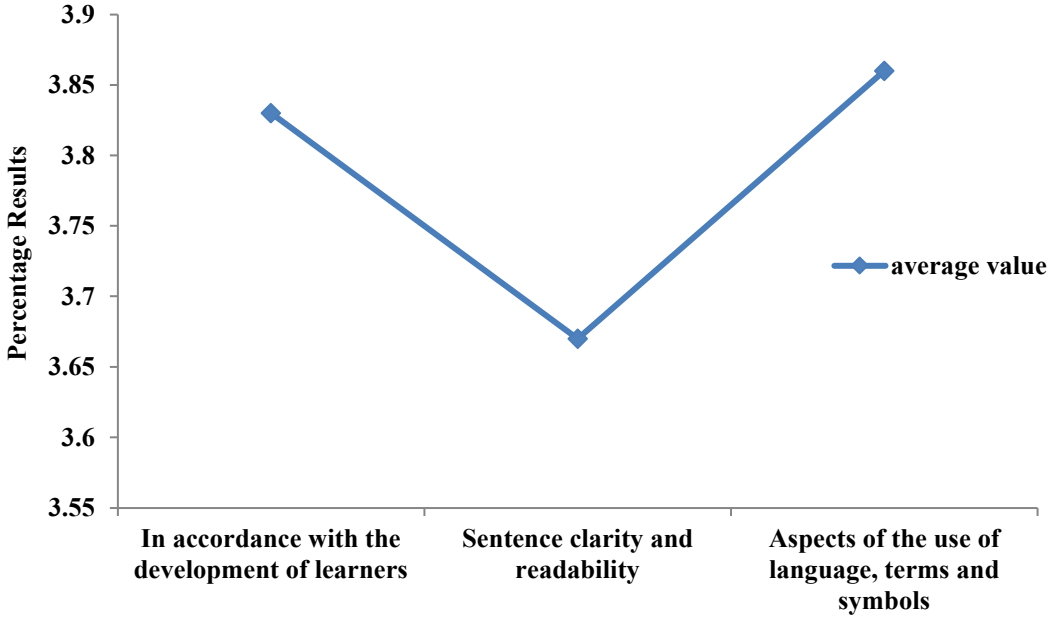

Figure 7. The Graphic Of The Results Of Language Feasibility Analysis Of Teaching Materials Developed

Adequacy of Presentation

The feasibility of the presentation used includes four aspects of assessment, namely presentation techniques, presentation support, module presentation and evaluation. The results of the analysis of the feasibility of presenting problem-based learning-based teaching materials are presented in Figure 8.

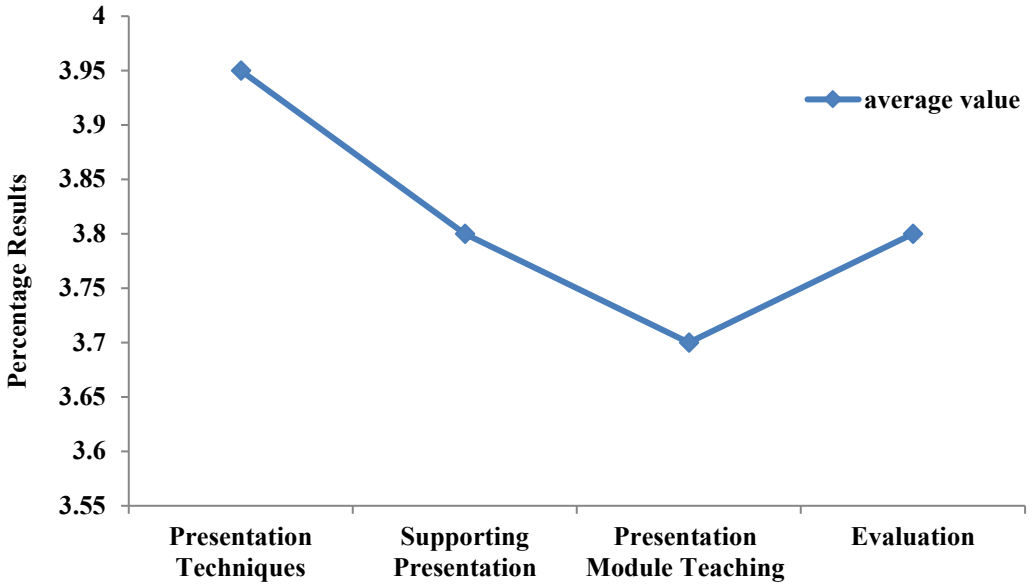

Figure 8. The Graphic Of The Results Of The Feasibility Analysis Of The Presentation Of The Developed Teaching Materials.

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All aspects of presentation feasibility have an average value of 3.77 including valid categories without the need for revision. This shows that based on the feasibility aspect of presenting teaching materials based on Problem Based Learning that has been developed it is suitable for use in chemistry learning for class X even semester.

Graphic Eligibility

The graphical feasibility aspects used include three aspects of assessment, namely module size, module cover design and module content design. The results of the analysis of Problem Based Learning-based teaching materials developed on the graphical feasibility aspect can be seen in Figure 9.

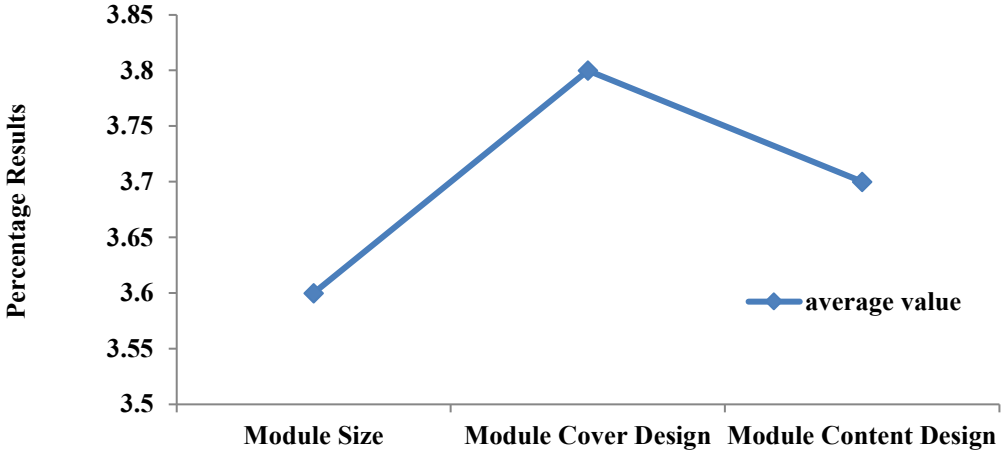

Figure 9. The Graphic Of Feasibility Analysis Results Developed Teaching Materials

Based on the results of the analysis that has been carried out on the graphical feasibility aspect, the average value for each indicator is 3.68; 3.70 and 3.75. All indicators on this aspect of graphic feasibility are in the valid category without revision. . This shows that based on the feasibility aspect the developed teaching materials are suitable for use in chemistry learning for class X even semester.

Conclusion

Based on this research, it can be concluded that this research and development produces a product in the form of problem-based learning-based teaching materials in even semester X class biology material. This research is developed using research and development or can be called (R&D). Teaching materials developed through the validation stage by three experts as validators, namely a biology lecturer and two biology teachers.The results of the feasibility analysis of the problem-based teaching materials developed obtained an average score of 3.86 (biology lecturer) and 3.73 (biology teacher) with valid categories without the need for revision and suitable for use in biology learning class X even semester.

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Digital literacy skills of biology students through ICT project assignment

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Abstract. *This study aims to determine the skills of digital literacy aspects in accessing, selecting, understanding, analyzing, verifying, and producing in biology students through ICT project assignments on algae material at Medan State University. This research uses a survey method. The instruments used were Likert scale product assessment sheets and interview instruments. Sampling as many as 44 students using simple random sampling. The technique of analyzing research data with descriptive quantitative. The results of the study Digital Literacy Skills are classified as good with an overall percentage of 79.25%, with the ability to access 77.08% of the good category, the ability to select 71.58% of the good category, the competence to understand with a percentage of 82.57% of the good category, with a percentage of 82.57% very good category, 80.48% competency to analyze with good category, competency to verify with good category, with a good category, competence verifies with a percentage of 88.06% very good category and producing competence with a percentage of 75.75% good category.*

Keywords: Digital Literacy, Biology, Assignment, ICT, Algae

Introduction

Students as the current generation are entering the world of digital literacy [1]. Due to the rapid advancement of Information and Communication Technology (ICT), causing digital literacy skills, information and technology to be as important as other general skills [2]. In general, digital literacy is considered a public policy in using the internet and digital media [3]. The development of digital literacy is an academic demand at different levels of education in Indonesia, especially at

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universities. Digital literacy is not just the ability to search, use and disseminate information, but requires the ability to make critical information and evaluate it, the accuracy of the applications used and a deep understanding of the information content contained in digital.

On the other hand, digital literacy includes responsibility for every information dissemination it does because of its impact on society. Today's students are becoming addicts because they often search on Google rather than opening books as references. This shows that the internet offers various needs in finding information. However, the lack of knowledge about digital literacy is a serious obstacle in its implementation. its application. One of the efforts that can be made is to equip students with digital literacy skills to explore digital information wisely [1].

Based on the results of interviews conducted by biology students of PSPB 21 A batch at Medan State University, the internet is the main need in finding algae material in making algae species projects. However, the obstacles in making this algae species book project are (1) difficulty in finding the classification of each species, because the assignment of each group of species cannot be the same, so some students find it difficult to find the classification of species and choose to copy and paste from the website obtained without ensuring the correctness of the website (2) difficulty in finding pictures of these species, so they take pictures from websites that are not known to be correct (3) copy and paste material, so that the bibliography is not included. This happens when students cannot find references to the desired material or species.Some students did not care about the accuracy of the sources of information obtained and focused only on completing the project assignment, without checking the suitability of the sources of information in the species book project.

One of the courses that applies this project assignment is Taxonomy of Low Level Organisms (TOTR). Taxonomy of Low Level Organisms is a course that studies archaebacteria and eubacteria, protists, functions, lichen, bryophyta and pteridophyta. Each of these materials discusses starting from understanding, characteristics, habitat, reproduction, classification and role. This course also conducts practicum in the laboratory to identify certain species, and then is required to do 6 KKNI assignments. Working on this task, of course, digital literacy skills are needed by students in finding information sources, one of which is project assignments. Project assignments are student group assignments that aim to train students in organizing an activity in the form of a project.

The project task was designed using ICT (Information and Communication Technology), with the provisions that the task be done in group, projects in the form of applications, material based on relevant sources, each group of species must be different, have a source of images and species classification. ICT-based projects will help students access, collect, process and display or convey messages both written and visual using technology. With ICT, information can be presented with a variety of digital displays such as images, movies, audio, text or a combination of all [4]. So that students must be able to use digital literacy carefully, because one of the success factors of learning is the ability to find the information needed on digital/internet networks [2].

According to Nasionalita& Nugroho there are two (2) problems: First, the information spread on the internet varies from factual information to fictitious information[5]. Information spreads quickly and rapidly and cannot be blocked. The inability to act and manage information leads to worse conditions than information overload. Second, the scope of information content creation lies in the bargaining power of information and communication technology that creates opportunities for the deliberate creation of information as a commodity that causes disinformation. Disinformation is dangerous misinformation. Students' ability to evaluate and apply information

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sources is still lacking. Students can usually search for information using applications on the Internet, but ignore inappropriate information.

On the other hand, the existence of negative content that damages the current digital ecosystem can only be responded to by building awareness from each individual. Being digitally literate means being able to process information, understand messages and communicate effectively with others in various forms. In this case, the form in question creates, elaborates, communicates, and works according to ethical rules and understands when and how technology should be used to be more effective in achieving goals [6].

Based on these problems, this study was conducted to examine how the level of digital literacy competence of biology students with the assignment of TOTR course projects at UNIMED on algae meters in the use of media or selection of information to be made in the project.

Method

Research Method

In this study, a survey method with descriptive research was used, namely finding in-depth facts about existing symptoms and factual information using research tools. Product evaluation instruments and interviews are the tools of this research, which were given to 44 respondents using simple random sampling. The product evaluation instrument is the main data of this research which is closed in nature which aims to obtain primary data on students' digital literacy. Interviews for this study were conducted to obtain what were the obstacles and constraints when working on ICT projects. Both tools are based on aspects of digital competence, namely access, selection, comprehension, analysis, verification, and production.

The product assessment sheet uses Likert Scale measurement. The answer scale on the Likert Scale for each answer is made the highest score is 4 and the lowest score is 1. For answers Very good (VG), given a score of 4; Good (G), given a score of 3; Less Good (LG), given a score of 2; and Not Good, given a score of 1[3].

Data Analysis

Data analysis of student product assessment sheet student product assessment sheet using the formula as follows:

$$P = \frac{\sum}{N} x\ 100\% \quad (1)$$

Description:

P: Score presentation

∑: Total Answer Score obtained

N: Total Ideal Score [7]

Then, this study divides into 4 (three) intervals of percentage of digital literacy assessment criteria, namely the digital literacy index category is not good 25% ≤ 43.75%; digital literacy index category is not good 43.75% ≤ 62.50%; digital literacy index category is good 62.50% ≤ 81.25%; digital literacy index category is very good 81.25% ≤ 100% [7].

Research Procedures

Identifying stage :

a. Students are able to identify protists by classifying protists including algae or protozoa based on the results of observations
b. Students are able to describe the characteristics of algae based on observations

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Project Work Phase :

a. Students are able to describe grouping based on taxonomic classification and are able to classify based on the results of observations and literature studies
b. Applications are needed to support the success of student algae ICT projects such as Adobe Photoshop, Coreldraw, PichArt, Canva, iNaturalist, Pinterest, Youtube and Capcut.
c. Websites contributed to the completion of this project, namely Google Lens, ITIS (Integrated Taxonomic Information System), Google Scholar, ResearchGate, Tuwaifu and Google Voice.
d. The final result of the algae ICT project will be in the form of an application that is uploaded in the form of a google drive: such as Flip Pdf Professional and Flip PDF corporate.
e. Assessment of the content of the project, namely: Algae ICT Project Cover, Foreword, Table of Contents, Introduction to Algae, Concept Map (species name, family, class and division.), Description (color, shape, flagellum, size, habitat and reproduction), Images of algae species and sources, Videos of algae species and sources, Glossary and Bibliography.

Result and Discussion

Aspects of Accessing

In terms of the ability to use web search engines, students are required to access journals (national / international), books, textbooks and access modules as relevant sources of information in working on algae ICT projects contained in citations and bibliographies. Students are also required to be able to use certain websites as a source of material or image information such as Google Lens, Google Scholar and ITIS (Integrated Taxonomic Information System).

Students show the use of web search engines in the good category with a percentage of 64.39%, this is indicated by students being able to utilize journals (national / international) and books / textbooks. However, students have not fully used the module as a reference source, even though the module is also used as a student learning resource.

In identifying algae species, students certainly use Google lens as a first step in finding species names based on observations in the laboratory. Google lens is one of the learning media related to image features and its use utilizes skills in finding information to build knowledge independently [8] because Google Lens can search for species that have a similar level in identifying an object [9].

Table 1. The results of data analysis of digital literacy skills obtained from product assessment sheets on aspects of accessing.

Aspects	Indicators	%	Category
Accessing	Able to use search engines	64,39	Good
	Able to use software	89,77	Very Good
	Average	**77,08**	**Good**

In identifying algae species, the ITIS (Integrated Taxonomic Information System) website also plays an important role in knowing the taxonomy of algae species found. But unfortunately, only a few students use the ITIS website. This is because students do not understand how to operate the website. Without realizing it, this site is the best first step in finding information, which uses the Traditional Linnean nomenclature system (not the phylogenic one) in the kingdom of protists [10]. ITIS has classification data for the species we are looking for, lists species of the same genus, species year, species images, metrics and data on species found and species taxon references.

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After identifying the algae species, students used Google Scholar and ResearchGate to find information on the species they were looking for. In research Rafika et al, Khairiyah & Marlini, explained that Google Scholar presents citations of various kinds of science such as natural knowledge, general knowledge and technology that students can use as a reference source in making their scientific work such as journals, papers, and articles. making scientific works such as journals, papers, and other manuscripts to obtain valid information and references related to their research [11,12].

ResearchGate also has the same role as Google Scholar, which provides quick and easy access to finding relevant sources. It is supported in research Aravik et al, Singson & Amees, Meier &Tunger said that ResearchGate can be used as a source of literacy in searching for scientific papers or finding literature in a free, easy and practical way for the general public, has many facets of visibility, accessibility, collaboration and most importantly the latest research updates [13–15].

In using these devices, students must choose the right application / software that will be uploaded in the form of Google Drive. Students must use Google Voice as a voice medium. Students' ability to use the device is very good with a percentage of 89.77%, this is indicated by the selection of applications/software that is easy to carry out projects and simple in its application. Students also upload projects on Google Drive in the form of applications in the form of flip pdf professional demo, flip pdf corperate edition, and flip pdf plus pro. Applications can help in completing projects, such as including videos, audio species and flash animations that support project completion. This application also provides interesting and interactive learning [16].In the species audio is a sound media used to help introduce the algae found based on observations, students have applied Google Voice as a video sound media and set the speed of sound, pronunciation and language in absorbing information clearly. The application to support the creation of this species video, students only need to use CapCut and the Google Voice website, because these two things are quite helpful in creating project video content.

Students' digital literacy skills in accessing are classified as good with 77.08%, but based on interviews there are several obstacles experienced by students in using the flip pdf application used 1) students do not know or do not know how to distinguish flip pdf web with flip pdf applications, so there are three groups uploading projects using links; 2) flip pdf in the form of a web cannot run videos; 3) some project applications can only display 12 pages, so the file cannot be displayed as a whole; 4) the application must be premium so that application errors often occur such as outgoing applications that result in re-entry of data; 5) there is a watermark display and storage is quite large.

Aspects of Selecting

In selecting, students must have the ability to search for information from various applications, which means requiring students to take videos and images from YouTube and use iNaturalist and Pinterest as sources of images listed in the citations. Students' ability to find information from various applications is good with a proportion of 65.90%. This is because students take videos from YouTube with the best HD (High Definition) quality with 1080 HD and 720 HD quality so that the video displays clearly. YouTube is the main source of videos about successful algae ICT projects. This is because YouTube certainly offers a wider variety of videos and accessing them is easy and fast.

This means that students need to retrieve videos and images from YouTube and use iNaturalist and Pinterest as sources of images listed in the citations. Students' ability to search for information

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from various applications is good with a proportion of 65.90%. This is This is because students take videos from YouTube with the best HD (High Definition) quality with 1080 HD and 720 HD quality so that the video displays clearly. YouTube is the main source of videos about successful algae ICT projects. This is because YouTube certainly offers a wider variety of videos and accessing them is easy and fast.

However, none of the students used YouTube as a source of images. Most students tend to use images.app.goo.gl, google.com, sciencephoto.com, Wikipedia.org, protist.i.hosei.ac.jp, melekperikanan.com and other sites. While the iNaturalist and Pinterest applications are neglected, only a few students use these applications as a source of images, this is known from the percentage results which are 40.9% only.

Table 2. The results of data analysis of digital literacy skills obtained from product assessment sheets on the aspect of selecting.

Aspects	Indicators	%	Category
Accessing	Selecting Able to search for information from various applications	65,90	Good
	Able to select appropriate information	77,27	Good
	Average	**71,58**	**Good**

The Naturalist platform provides good coverage because it can facilitate communication between scientists and observers [17], iNaturalist can also explore species that are nearby, can display photos, videos and can identify through voice [18,19]. Inatularist also provides quality levels based on quality levels based on research grade qualifications. The quality level summarizes the accuracy, precision, completeness of an Inaturalist observation as biodiversity data.

In addition to inaturalist, digital media is used as a student learning media both to find visual information content and present ideas in the form of attractive images, namely Pinterest. In research (Pratiwinindya et al.,Edytia&Sahputra stated that Pinterest media is most suitable for optimizing students' visual literacy, because it has features that users use to receive information more specifically and accurately according to what they are looking for[20,21].

Students must also be skilled in selecting appropriate information, which means encouraging students to be able to use books, journals and modules according to the needs of the algae project content. The ability to choose appropriate information is in the good category with a percentage of 77.27%. This can be seen by students taking journals, books and modules according to project needs, students are not careless in taking reference sources that are outlined in their projects.

However, student project analysis does not use journals, books and modules as a source of images seen from the citation of algae species. This is true, based on the results of interviews some students have difficulty choosing journals (national or international). One of them, some students have not been able to distinguish between national and international journals, so students assume that if the journal title is in English then the journal is international.

Then, students find national journals but do not display images, so they choose websites and blogs as a source of images that are faster and brighter image quality. Students also do not use books as a source of images, because many of the books they find are not in color. Although students rely too much on websites or Google blogs, students can include source citations in every picture and video taken, because this is an assessment of the algae ICT project assignment. So it can be said that the competence of choosing in digital literacy has an average percentage of 71.58% in the good category.

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Aspects of Understanding

The ability to understand written messages in algae ICT projects means thatstudents are required to have project design skills and support color selection. Students are also able to write the division, class, family of each algae species name, because it is one of the aspects assessed in the project. Students' ability to understand written messages is very good with a percentage of 85.60%, this is indicated by students being able to design projects with matching colors of layout elements so as to clarify functions. Students are also able to choose appropriate colors so as to support the suitability between the creative concept and the chosen topic. The selection of colors for project results does not only use one color, students instead combine a variety of colors and attractive templates. So that the layout in writing the classification of algae species, especially divisions, classes, families, becomes interesting.

Table 3. The results of data analysis of digital literacy skills obtained from product assessment sheets on the aspect of understanding

Aspects	Indicators	%	Category
Accessing	Understanding written messages	85,60	Very Good
	Understanding the video	79,54	Good
	Average	**82,57**	**Very Good**

Students must also be able to understand the video, which means organizing the motion of the video content delivered. Student analysis in understanding the video shows good with a percentage of 77.27%. Students can adjust the movement with the video content presented by explaining the shape, size, means of movement, color, habitat and reproduction in the species video and still pay attention to pronunciation, fast and slow sounds and effective language used in the species video.

Digital literacy skills in the understanding aspect are classified as very good with an average percentage of 82.57%, because based on interviews students are able to use CapCut, Canva and supporting applications such as Piktochart. The three applications have their respective functions in the success of the algae ICT project. Capcut is a video editing application for creating animations and can add video sound and the type of sound you want. Based on research (Deriyan&Nurmairina the existence of capcut can indeed help and facilitate users to create and edit various kinds of videos they want[22]. In research Markus and Ismaun said that this application capcut offers many interesting features for creating long and short videos, ranging from video cutting, inserting text, photos, and animations, inserting videos into videos (overlay), adding music, stickers, and other features [23,24].

The Canva application is used as a design template provider application that is widely used for free [25]. Canva also makes it easier for students to understand lessons because the display of text, animation, graphics and others is in accordance with the desired appearance so that it displays a creative impression [26]. Meanwhile, the application used to develop project concepts and provide easy color change options so that infographics with different nuances can be displayed is Piktochart [25].

Aspects of Analyzing

Students who are able to understand the meaning of information based on format means that it requires students to vary the size of the forn in writing, compile projects with consistent content

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and the accuracy of writing terms in the algae ICT project. Students must also be able to master the writing of algae species classification terms. Based on the analysis, students' ability to understand the meaning of information based on format is very good with a percentage of 84.84%.

Table 4. The results of the data analysis of digital literacy skills obtained from the product assessment sheet on the aspect of analyzing

Aspects	Indicators	%	Category
Accessing	Able to understand the meaning of information based on format	84,84	Very Good
	Able to relate information to the purpose of the message maker	76,13	Good
	Average	**80,48**	**Good**

This is indicated by the ability of students to vary the size of the shape in writing the name of the species, family and all aspects of writing the algae ICT project including image sources to support the content of the message without overdoing it. Students can also organize projects with mixed content ranging from content introduction, concept maps, descriptions, images/video of species, image/video sources, and glossaries. Students are also able to master the writing of taxonomic classifications, the accuracy of writing the names of species, families, divisions according to the scientific field.

Students are also able to connect information with the purpose of the message maker, encouraging students to avoid plagiarism. Students are also required to match the materials, videos, images presented in the algae ICT project. in the algae ICT project. The ability of students to connect information with the purpose of the message maker is classified as good with a percentage of 76.13%. In adjusting the material, videos and images presented in the project, students are quite good at it. However, in filling out the algae description material is classified as poor, most students do not paraphrase the description of the algae species outlined in their project with a percentage of only 56.81%.

It is known that almost all the contents of each student's project description are copied and pasted from websites such as *Wikipedia.org, melekperikanan.com blog, academia.edu, respositori.ub.ac.id, id.thparonama.com and dasatop.lecture.ub.ac.id* and quoted from journals but the journal is not listed in the Bibliography. From the interview results, students copy and paste from the site, but do not paraphrase the writing so that the content looks the same with the same wording. This is because students think that Wikipedia and Akademia.edu are trusted websites, just by looking at the bibliography, the names listed and the similarity of the content of the material.

But please note, some sites or blogs cannot be confirmed as to the truth of the information included. This is because it is not certain who published the information or who is responsible for the accuracy of the information on the site or blog. Even if the site includes the author's name, it is not known whether the writing is original or a quote from another source. If the writing is original, it cannot be known whether the author has the competence or eligibility to make the statement [27]. This is supported by research Makmur et al., saying that wikipedia is sometimes considered a less accountable source [28].

Likewise, Google blogs participate in sources of information about student algae ICT projects. Don't just look at the efficiency and speed of finding information, but also pay attention to the truth in the blog. Research Maryulis states that blog content can contain anything according to the will

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of the owner [29]. They can post opinions, brief information, complaints, photos, videos, or copy and paste from other blogs. Do not be surprised if in searching for the desired information, there is more than one information that is exactly the same.

Aspects of Verifying

The ability to confirm is to be able to prove and confirm the truth of various sources of information and decide to take reliable sources of information in the preparation of the algae ICT project.Students are able to compare information from various sources of information, where students are required to be able to include sources of information through citations and bibliographies. The ability of students to include sources is classified as good from each picture and video that is poured into the project through citations, obtained a percentage of 79.54%. In this study, some groups did not include the source of images and videos. images and videos. This is indeed trivial students to video and image citations, because students are more concerned with completing projects on time. Without realizing it, citations can provide clarity on the source of videos or images so that their accuracy is known. In research Kosasi said that ensuring citations or citations related to references is needed so that it can avoid plagiarism [30].

Students are able to decide on reliable information, directing students to rigor in choosing sources of information such as journals and books. The results of student analysis proved to be very good with a percentage of 96.59%. This can be seen by students in determining the journal used, seen from the identity of the journal starting from the type of journal, title, author's name, number, volume, year of publication and number of pages. Likewise with the books used, students include the identity of the book as a definite reference, seen from the completeness of the identity of the book title, author, publisher, year of publication, and ISBN.

Table 5. The results of data analysis of digital literacy skills obtained from product assessment sheets on aspects of verifying.

Aspects	Indicators	%	Category
Accessing	Able to compare information from various sources of information	79,54	Good
	Able to decide reliable sources of information	96,59	Very Good
	Average	**88,06**	**Very Good**

The digital literacy competence of the verification aspect is classified as very good with an average percentage of 88.06%, this is in line with the results of student interviews who use journal and book references by ensuring their authenticity based on the completeness of the reference identity. This is in line with research Mustati& HM which states that journals are information and communication media regarding materials, references, and even scientific research journals needed by students [31]. Books are also the main source of information for students who can deepen the content of an article or scientific work. Students consider that the use of books greatly affects the quality of the writing or work produced [32].

Aspects of Producing

In terms of producing, students can create images according to the objectives of the algae ICT project and use written or spoken messages but still pay attention to good and correct language. Producing also means being able to compile, initiate ideas, plan and improve messages, both in the form of images or videos taken from other digital sources. Competence in the aspect of

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producing students is classified as good with an overall presentation result of 75.75%, this is because students have the ability to make written messages skillfully make photo or image messages and are able to make video messages.

Students must have the ability to write written messages. This means that students must be able to explain species descriptions and pay attention to writing bibliographical books and journals on algae ICT projects. Students' ability to create written messages is classified as good with a percentage of 72.72%. This can be seen from the students' ability to describe algae species in the project, which can explain shape, size, mobility, habitat color and reproduction.

Table 6. The results of the data analysis of digital literacy skills obtained from the product assessment sheet on the aspect of producing

Aspects	Indicators	%	Category
Accessing	Able to create messages written	72,72	Good
	Able to create a message photo/image	84,09	Very Good
	Able to create a message video	70,45	Good
	Average	**75,75**	**Good**

In writing a bibliography for books, students still pay less attention to the slash of the book title, the year of the book in parentheses and indented into the bibliography, so that the percentage result is only 54.54%. This is because students are negligent in writing a good bibliography. The skill in transferring the bibliography to the project is very weak. This is because students tend to focus on completing the algae ICT project only. However, the writing of the journal bibliography is still quite good. Although some students do not use slashes in the type of journal and the writing is not indented.

It should be noted that writing a bibliography is the success of digital literacy skills, because writing a bibliography is the ability of writing a list that lists book specifications or reference sources and has an important role in an essay because basically writing that does not include a bibliography is very doubtful of its scientific level or is still a work of fiction [33]. Thus, writing a good bibliography is an assessment in the algae ICT project.

Students must also be able to create photo/video messages, which means encouraging students to design covers according to the contents of the algae ICT project. From the analysis of the results, it is stated that the ability to design a cover in accordance with the contents of the project and make an attractive cover design starting from color, font and background is classified as very good with a percentage of 84.09%. . This is because students are able to apply Canva as a tool in finding interesting cover templates. Canva application is the only application used in making covers for algae ICT projects.

Conclusion

The results of research and analysis of the Digital Literacy Skills of Biology Students with ICT Project Assignments on Algae Material at Medan State University, it can be concluded that the digital literacy skills of biology students in Class 2022 on algae material are classified as good as 44 students with an overall percentage result of 79.25%. With the ability to access 77.08% in the good category, the ability to select 71.58% in the good category, the competency to understand with a percentage of 82.57% in the very good category, the competency to analyze 80.48% in the

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good category, the competency to verify with a percentage of 88.06% in the very good category and the competency to produce with a percentage of 75.75% in the good category.

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Multiple representation – based earning media about human organ System for secondary biology classroom

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Abstract. *Multiple representation is a framework to present concepts in different representational modes and levels includes the level of macro, submicro and symbolic levels. The concept of human organ systems includes digestive system, excretory system, movement system, transportation system were selected to be developed as biology learning media for secondary students. About eights learning media produced by graduate students for two months through development steps of ADDIE (analyse-design-develop-implementation-evaluation) were analysed quantitatively and qualitatively based on aspects of learning material, learning media, and teacher and students responses into media use in the classroom. The results showed that there are various of students ability in identifying, selecting, and categorizing concept into macro, micro and symbolic level. Based on implementation into students and evaluation toward media uses, teacher and students promote positive responses about its valid, practical, useful and helpful media to understand concept of human organ system.*

Keywords *:* Human Organ System, Multiple Representation, Secondary Biology

Introduction

Science concepts are described in multiple ways of representation such as text, diagrams, analogies, models, equations, mathematical relationships and computer simulations as well as different representations such as the macro, submicro and symbolic levels. Teaching aims to help learners develop their understanding of the science concepts under investigation by considering these different representational modes and levels. One way to understand how these different representational modes and levels help learners is to consider their functions as discussed in the theoretical framework of Ainsworth.[1]

Science concepts are provided with a multitude of information in terms of text to read, words to listen to, experiments and activities, photographs, drawings, diagrams, models, charts, tables, equations, animations and simulations. These different modes of representation, used to depict scientific ideas, concepts or phenomena in a particular way, can be assumed as a continuum from concreteness to abstraction – from doing experiments to using language to listen to ideas or to express them. Basically, the purpose of these different modes of representing aspects of the same scientific ideas, concepts or phenomena is to allow learner develop his or her understanding of the scientific ideas, concepts or phenomena.

Chemistry and physics have their submacroscopic and symbolic representation in chemical and physical eplanation. [2]. While biology has four levels in which concepts are represented because of different organisation of biology knowledge. The macro level involves biological structures visible to the naked eye such as the plants and animals we see in our daily lives – making these observations was how the science of biology began. An additional level of representation in biology is the cellular where plant and animal cell structures invisible to the naked human eye are visible under a light microscope and sub-cellular

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structures visible under electron microscope. The submicro or molecular level involves DNA or proteins identified using analytical tools such as electrophoresis, chromatography, or a centrifuge, in the case of genetics representing inheritance patterns through genotypes or inheritance patterns, and for evolution using phylogenetic trees. Multiple representations can be found in every concept of science education teaching and learning. For example, science textbooks often show more than one representation on a single page. One or more representations as photographs, drawings, diagrams, models, charts, tables, or equations can be found in every textbook. The reader needs to be able to understand logically and analyse why, say, a paragraph about increased heart rate during exercise also has a heart rate - time graph and a picture of a track athlete. The graph can provide information complementary to the text and provide deeper understanding of the concept or it could constrain the meaning of the text. To learn science concepts with these different representations, students need to analyse them in order to make judgements about their utility in helping make scientific explanations. To increase students' interest in science, teachers and curriculum specialists provide experiments or demonstrations as well animations and simulations. Without appreciating the vantage point of the different representations, it would not be possible to have full understanding of science [3]

There are number of theories to best explain learning with multiple representations. One theoretical framework, tpromoted by Ainsworth describes the pedagogical functions of external representations in learning, namely to complement information and cognitive processes, to constrain interpretation/misinterpretation of phenomena, and to construct deeper understanding in problem solving and reasoning. [4]

Though using diagrams, charts, pictures, and models is common classroom practice, careful consideration of the psychological processes of learning will aid educators in optimizing student learning from these visual representations. Theories of learning from multiple representations have generally focused on how to engage cognitive resources effectively and avoid high demand that is not intrinsic to the conceptual aspects of the intended task.[5][6]. Theories of multimedia learning build on this foundation to describe how learners make sense of text and pictures presented together. While well-designed instruction that includes text and media together may enhance learning, the processes whereby learners make sense of both textual and visual input within the cognitive architecture are complex. [7]. Complementary representations, which are designed to highlight comparisons across diagrams, as in the case of the related processes of photosynthesis and respiration, may be particularly difficult for learners to process. [8]

Previous studies showed various biology learning media to help students understand human organ system better. Animation, torso, and the picture have been used to increase senior high students learning ourcome of digestion system. The quasi experiment was implemented into three classes. First experimental class use animation, second experiment class use torso, while control class uses picture. Multiple-choice questions were administered to measure learning outcomes, while critical thinking skills are essay-based. Data analysis technique using Covarian Analysis (Anacova) at significant level α= 0,05 and continued with Tukey test with SPSS 21.0 software showed influence of animation media to student learning outcomes (F= 4,266; P= 0.017). Students taught by using animation media were significantly different from those taught by using picture media, but not significantly different from those taught by torso media. The research shows that learning human digestive system by using animation media influenced better to their learning outcomes.[9]

Another R&D study concerning on developing scientific approach-based interactive learning media have been conducted to support students learn topic *Auditory System in Living*

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Things. Through quasy experiment method, the results showed that the interactive learning media were obviously suitable and appropriate to be used in learning process for 8-grade students. The teacher's perception about the development of learning media was categorized as extremely required. The result of validator assessment into media showed percentage from the material experts 90,77% and it was categorized as extremely good and the design's experts on the learning media approximately 90% and it was categorized extremely good. The study showed that the scientific approach-based interactive learning media on the topic of auditory system in living things was effective applied to the 8-grade junior high school. [10]

Adobe Flash CS3 has been applied to develop learning media of nervous system with for 11-grade high school student. Through expert assessment, it obtained positive response from media expert (89%); teaching learning biology expert (83%) and students respons (91%). All responses into biology learning media developed with Adobe Flash CS 3 of nervous system for high school student is categorived as very good. [11]

Biology interactive learning media based macromedia flash in the material of Human Digestive System was also developed for senior high school. Through three times trials into 36 students, then 85 students, then 165 students the results showed its eligibility material content is in very good criteria (88%), the language of learning media is in very good criteria (85%), the media development product is in very good criteria (84%), teacher responses is in helping criteria (4,4) and students are in very good criteria (82,7). [12]

Methodhology

This descriptive study aims to analyze multiple representation – based learning media on various topics of secondary biology developed by graduate Biology students. About 14 multiple representation – based biology learning media have been analyzed quantitatively and qualitatively. All biology learning media have been developed through the step of ADDIE model (analyze-design-develop-implementation-evaluation) and implemented into Senior High School for two months. The topic selected promoted into media includes digestive system, excretory system, movement system, transportation system. The product of media were analysed based on aspect of representation level includes macro, micro, and symbolic levels.[13]

Results And Discussion

There are eights selected learning media developed based on multiple representation consist of two medias of human transportation system, two medias of human excretory system, two medias ofhuman movement system, and two medias of human digestive system, the result showed as follow.

The table showed that same topic promoted different sub topic to developed into multiple representation – based learning media. Generally all topics have been explained into more specific level. Types of media are also different preseantation begin with picture, model, pocket book, audio visual, into animation video. When it is explained into more specific level, macro level, sub micro level, into symbolic level, we can see various ways to select. Some still in general concept, another deep into more specific of disorder or symthom. For example, the concept of human transportation system, one media keep holding human transportation system in macro level as general. While another media has focusing on leukemia in macro level, so that lead into process of leukemia at micro level, until symptom at symbolic level .[14]

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Table 1 Description of Macro, micro, and symbolic level of multiple represtation – based Biology Learning Mediaabout Human Organ Systems

Topic	Sub topic	Macro Level	Micro Level	Symbolic Level
Human Transportatio nSystem	Leukemia	Model of blood structure of normal and leukemia suffer	Animation video of theprocess of leukemia	Animation video of symthom and type of leukemia
Human Transportatio nSystem	Human Transportatio nSystem	Model of Transportation system	Animation video of transportation systemdisorder	Animation video of how transportation organs work
Human Excretion System,	Kidney	Video about kidneydisorder	Model of nefron	Model of how kidney works: filtration, reabsorbtion, augmentation
Human Excretion System,	Kidney	Model of kidney	Animation video ofnefron struktur	Animation video of symthom and how do kidney stones form
Human Movemen tSystem	Bone	Model of bone	Video of ossification process	Animation video of osteophytes symthom
Human Movemen tSystem	Joint disorder	Picture of jointdisorder	Picture of types of jointdisorder	Picture of joint dislocation
Human Digestive System	Celiac disease	Picture of normal intestine and celiac suffered intestine	Animation video ofceliac disease in intestine	Animation video of celiacdisease: symthom and diagnosis
Human Digestive System	Human Digestiv eSystem	Pocket book, picture of human digestivesystem	Pocket book, digestivesystem disorders	Pocket book, digestive mechanism: mecanic andchemical digestion

Two medias about human excretion system represented same sub concept about kidney at macro level and nefron at submicro level, then separated differently at symbolic level. One media focus on mechanism of filtration, reabsorptoan and augmentation, while the other focus on how do kidney stones form. Certainly these different representations aim to help students understand learning difficulty of excretion system. [15]

These representation promotes different understanding and different ways to prioritize sub topic to learn. This allow students to help and motivate their way for learning better, because ths representation can promote student's further question. As Zhang said that without external aids, memory, thought and reasons are all constrained. [16]

Pedagogical functions that they play alongside their structural form should be considered to understand the ways that multiple representations could be designed to support learning. Multiple representations play a complementary role when learners exploit differences in computational properties or information by switching between representations and selecting the appropriate representation for the task at hand. Constraining benefits can be achieved when we support learners' understanding of a second representation by relating it to a familiar representation. Learners can obtain better and deeper understanding when they abstract over multiple representations to achieve insight into the nature of the representations and the domain.[17]

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Conclusion

Multiple representation – based Biology Learning Media developed by Biology Education graduate students have been assessed and categorized into valid according to material and media experts. Beside they are assumed as practical and easy use for students and teachers. Some difficulties to learn concepts of human organ systems includes digestive system, transportation system, excretion system, movement system especially some mechanism of how human organ works, how organ disorder and diseases happen, have been discusses and helped through using multiple representation- based biology learning media so that it is more easier to understand.

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Profiling creativity of undergraduates student in biology education through bullet journaling

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Abstract. *This research aims to determine the application of bullet journaling to the creativity of biology education students Class of 2020 FMIPA Medan State University. This type of research is quantitative descriptive research. The population of the research was all students from the Class of 2020 of the FMIPA Unimed biology education study program, while the sample was 30 students from the Class of 2020 of the FMIPA UNIMED biology education study program. Data collection was carried out through journal book documentation that had been carried out using a student creativity assessment rubric. Data were analyzed using descriptive statistics and then categorized following creativity categorization guidelines. The results obtained from this research based on creativity indicators for fluency and elaboration showed a very good level of creativity, while the indicators for flexibility and originality were in the good category. Total average value of undergraduates creativity through writing Bullet Journaling is Good category with score 67,2. Based on the bullet journal aspects observed (semester plans, motivation, task lists, lecture schedules, monthly plans), the number of students who received the very good creativity category was 49.34%, the good category was 25.33%, the adequate and poor categories were 3, 33%, and the unfavorable category was 18.67%.Therefore, it can be concluded thatoverall the creativity of students in the Class of 2020 biology education study program is in the Good category on all aspect of creativity, like fluency, flexibility, originality and elaboration.*

Keyword: Bullet Journaling, Learning Journal, Creativity, Metacognitive Awareness, biology education students.

Introduction

The Class of 2020 undergraduate students are students who are in semester 6 and have almost reached the final level of the undergraduate program. Class of 2020 students in the biology education study program will face many practical lectures to improve pedagogical skills and the ability to conduct research. Based on experience during teaching lectures in the sixth semester in

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the biology education study program, several problems were found that were often faced by students, namely increased stress levels which affected learning motivation and students' ability to manage their time. Busy schedules and the large number of tasks that students have to do are the causes of their less effective time management [1]. Lecture assignments on campus, practice in the field such as 'Guided Teaching' s, and writing a thesis proposal are tasks that sixth semester students cannot avoid. Apart from that, online lectures implemented during the Covid 19 pandemic and limitations on social interaction made it difficult for students to understand the material and carry out assignments that seemed more numerous than when they lectured face to face [2].

Bullet journaling (BuJou) is also known as creative writing. Creativity here means having the ability to write something unique, and not being bound by a standard in writing. Students are free to write with writing style, color, use of standard or non-standard words, and even type of letters according to their imagination. This characteristic of BuJou is what differentiates it from reflective journals or ordinary study journals. By writing BuJou, students are expected to be able to train and develop their creativity. Creativity is one of the skills needed in the world of work. Biology education students are prospective teachers who are prepared to teach in the future, so creativity is really needed to be ready to face challenges in the world of work and be able to innovate in designing learning, media, and even assessments in the classroom. According to Bernie and Charles [3] creativity and innovation can grow from a learning environment that facilitates questions, patience, openness to new ideas, a high level of trust, and learning from mistakes and failures. Student creativity can be increased through skills such as: 1) effective communication skills, innovation and creativity, 2) analytical thinking skills, flexibility, 3) readiness to change, having the right attitudes and values, 4) negotiation skills and skills. persuasiveness, 5) time management skills, 6) problem solving abilities, and 7) adaptability, ability to lead and build a team [4].

The characteristics of creativity according to Munandar are categorized into two characteristics, namely cognitive characteristics (creative thinking) and affective characteristics (creative attitudes)[5]. Cognitive characteristics (creative thinking) include: 1) fluency thinking skills, namely the skill of generating many ideas, answers, solving problems or questions by providing many ways or suggestions. 2) flexible thinking skills (flexibility), namely the skill of producing a variety of ideas, answers or questions by looking at problems from different angles, and being able to look for many alternatives so that you can change your approach or way of thinking. 3) original thinking skills (originality), namely skills that give birth to new and unique expressions by thinking of unusual ways to express oneself and creating unusual combinations of parts or elements. 4) elaboration skills, namely the skill of enriching and developing an idea or product and adding or elaborating in detail on an object, idea or situation so that it becomes more interesting.

Students' writing creativity is very lacking and they tend to be accustomed to copy and paste culture. This can be seen when students are given individual assignments in writing papers in introductory educational administration courses, on average there is a tendency for the assignments they create to be the same because the assignments they create are downloaded from the internet, without knowing that their friends have downloaded the same assignments. Thus, to overcome this, there needs to be a method used to increase students' writing creativity, namely a method of writing personal experiences whose material can be adapted to the courses programmed by students. Students as the next generation of the nation's life structure, if they do

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not have creativity, especially in terms of writing, will not have ideas for developing their nation, because they are used to plagiarizing and will even become a consumer society [6].Based on the background of the problem above, this research aims to: 1) determine the overall level of student creativity seen from the bullet journal component; 2) classify the number of biology education students and the level of creativity obtained based on creativity aspects.

Methodology Research

The design of this research is to use descriptive quantitative methods with the aim of describing undergraduatesstudents' creativity through bullet journaling.The population in this study were all Biology Education students, FMIPA Unimed Class of 2020. The sample used in this research was 30 students using a random sampling technique.Undergraduate students' creativity is obtained from the results of students' work in writing in journals (Bullet Journaling). The results of the student's work or writing were observed and assessed according to indicators of creativity.The creativity assessment rubric can be seen in Table 1.

Table 1. Rubrics of Creativity on Bullet Journal

Aspect	Indicators	Score
Fluency	Shows at least four descriptors: Sparks lots of ideas, questions, provides lots of solutions, or suggestions for doing various things.	3
	Indicates at least 2-3 descriptors	2
	Indicates at least 1 descriptor	1
	Does not show any descriptors	0
Flexibility	Produce varied ideas, answers/statements, and can see a problem from different points of view.	3
	Indicates at least 2-3 descriptors	2
	Indicates at least 1 descriptor	1
	Does not show any descriptors	0
Originality	Carrying out new and unique ideas, thinking of unusual ways to express ideas, and being able to create unusual combinations of journal parts.	3
	Indicates at least 2-3 descriptors	2
	Indicates at least 1 descriptor	1
	Does not show any descriptors	0
Elaboration	Enriching and developing an idea and adding or detailing the details of an object, idea or situation so that it is more interesting.	3
	Indicates at least 2-3 descriptors	2
	Indicates at least 1 descriptor	1
	Does not show any descriptors	0

Data analysis in this research is quantitative descriptive analysis. Quantitative descriptive analysis in this research is in the form of percentage results for each student's level of creativity and metacognitive awareness. The steps for analyzing student creativity are as follows: First, give a score for each aspect according to the creativity scoring rubric that has been created. Second, measure (calculate the value) of creativity for each aspect (fluency, flexibility, originality and elaboration).

The formula for calculating the value of creativity isthe total number of scores per aspect obtained by students is divided by the maximum score for each aspect.Furthermore, the level of student creativity will be categorized based on standards of student creative ability including not

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good, poor, fair, good or very good. To categorize student creativity, ability categories are used which can be seen in Table 2.

Table 2. Guidelines for Student Creativity Level Categories

Value Range	Category
81 – 100	Verry Good
61 – 80	Good
41 – 60	Fair
21- 40	Poor
0 – 20	Not Good

Furthermore, this study also counted the number of undergraduate students who obtained each category of creativity through journal writing.Both overall and for each section of the bullet journal observed (semester plans, motivation, task lists, lecture schedules, monthly plans).

Result and Discussion

In general, this research data consists of the overall level of student creativity in filling out each bullet journal component and the number of students along with creativity categories for each aspect of creativity (Fluency, Flexibility, Originality, and Elaboration). The first data, the average student creativity score via bullet journal with aspects observed including semester plans, motivational writing, task lists, course schedules and semester plans can be seen in Table 3.

Table 3. Average Value of Undergraduate Student Creativity Through Writing Bullet Journaling

Aspects Observed in Bullet Journals	Number of Samples	Mean	Standard Deviation	Category
Semester Plan	30	59	38,03	Cukup
Motivation	30	81	32,38	Sangat Baik
Task List	30	63	41,96	Baik
Course Schedule	30	48	34,87	Cukup
Monthly Plan	30	85	18	Sangat Baik
Total Nilai Rata-rata		67,2		Good

Semester Plan is part of bullet journaling which gives students the opportunity to outline semester achievement targets and what plans they have to make to achieve the targets. The semester plan written is a plan for lecture activities that they will face in the Odd semester 2023-2024. The Motivation component is a part of bullet journaling that is provided for students to write inspirational sentences that provide enthusiasm for carrying out lectures and the assignments they will face. In the Task List section, students write the assignments that have been given by the lecturer and the deadline for submitting them. The lecture schedule is filled with the name of the course, time (time and day) and lecture room. The final section, namely the Monthly Plan, is a section filled with plans for what students will do regarding academic activities both on campus and outside campus. The monthly plans collected in this research consisted of three months, namely June, July and August, then from these three months the average score was taken.

Based on the data obtained in Table 3, it shows that students' abilities in creative writing through bullet journaling are good. Students are able to write motivational sentences and

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monthly plans that will be carried out very well. Students are able to make motivational sentences that describe their respective conditions, while in the monthly plan section students write a list of activities they will do. The students' monthly plan section also writes down methods or strategies for carrying out activities and self-reflection regarding the impact of these activities and what obstacles and conveniences they face in the activities they carry out. This shows that writing motivational sentences and monthly plans contributes to student creativity in the final semester (Class of 2020). Beaulieu states that the importance of higher education and increasing imagination, originality, curiosity, and flexibility as well as being able to take risks to try new approaches in problem posing and problem solving by students [7].

Table 4. Undergraduate Student Creativity Through Bullet Journal Writing

Aspect Creativity of Bullet Journaling	N	SD	Mean	Category
Semester Plan				
Fluency	30	37,29	57	Fair
Flexibility	30	39,54	60	Fair
Originality	30	40,19	61	Good
Elaboration	30	39,08	58	Fair
Motivation				
Fluency	30	33,60	82	Very Good
Flexibility	30	32,38	81	Very Good
Originality	30	32,38	81	Very Good
Elaboration	30	32,38	81	Very Good
Task List				
Fluency	30	43,71	64	Good
Flexibility	30	42,65	62	Good
Originality	30	43,77	67	Good
Elaboration	30	42,60	59	Fair
Course Schedule				
Fluency	30	34,57	47	Fair
Flexibility	30	34,45	46	Fair
Originality	30	36,86	49	Fair
Elaboration	30	36,88	50	Fair
Monthly Plan				
Fluency	30	13,84	89	Very Good
Flexibility	30	19,21	81	Good
Originality	30	16,27	80	Very Good
Elaboration	30	19,30	84	Very Good

Based on Table 4 of the components of writing motivation in the bullet journal, the average value of student creativity in the dimensions of fluency, flexibility, originality and elaboration is in the very good category. Meanwhile, the component of writing a lecture schedule is in the fair category.This data shows that the majority of students write their lecture schedules following habits that are carried out without any innovation. This means that students write their class schedule in bullet journaling still using the pattern/design provided by the university, such as writing the day, time, name of the course, and the lecturer and the classroom where they will lecture.Korableva, et., all., in Borodina, T., Sibgatullina, A., &Gizatullina, A., also stated that an educational environment with standard assignments influences the level of student creativity. In fact, students should be free to write interesting lecture schedules according to their creativity [8].

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The second data in this research is the distribution/frequency of the number of students and their level of creativity in each component of the bullet journal and seen from the dimensions/aspects of creativity (Fluency, Flexibility, Originality, and Elaboration).**Figure 1** shows the number of students who achieved the dimensions/aspects of creativity in the category'Good' in the Semester Plan and Course Schedule bullet journal components. Semester plan, as many as 8 students have low/not good creativity in all dimensions. This shows that 26.7% of biology education students in the final semester were unable to write their semester plans fluently, variedly, uniquely and thoroughly. Meanwhile, in the Lecture Schedule component, 30% of students cannot write a varied, unique and thorough lecture schedule.

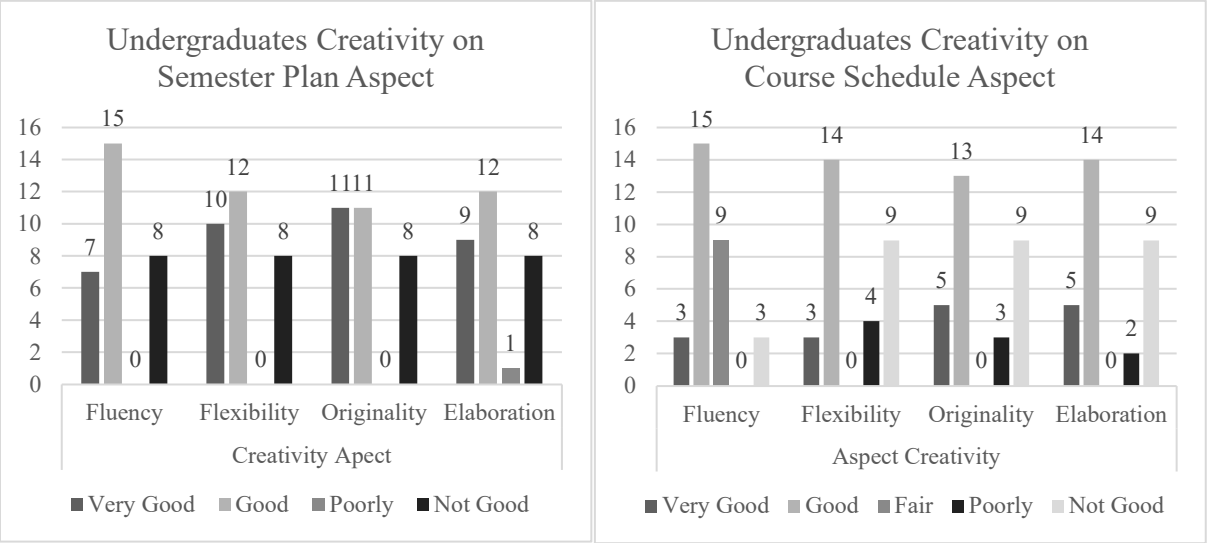

Figure 1. Distribution of data on the number of students who predominantly reach the Good category in the creativity dimensions Fluency, Flexibility, Originality and Elaboration for Aspects of Semester Plans and Lecture Schedules in the Bullet Journal

Figure 2 shows the number of students who achieved the dimensions/aspects of creativity in the categories very good in the bullet journal components of the motivation, task list and monthly plan.In the motivation writing component, the level of student creativity was highest in the very good category for all aspects of creativity. Likewise, for the monthly plan components in student bullet journals in the very good category, the frequency is highest in the dimensions of fluency, flexibility, originality and elaboration.So it can be concluded that the three components of the bullet journal in Figure 2, the dominant dimensions of student creativity are in the very good category. However, in the Monthly Plan component there were no students whose creative abilities received a bad or not good category.

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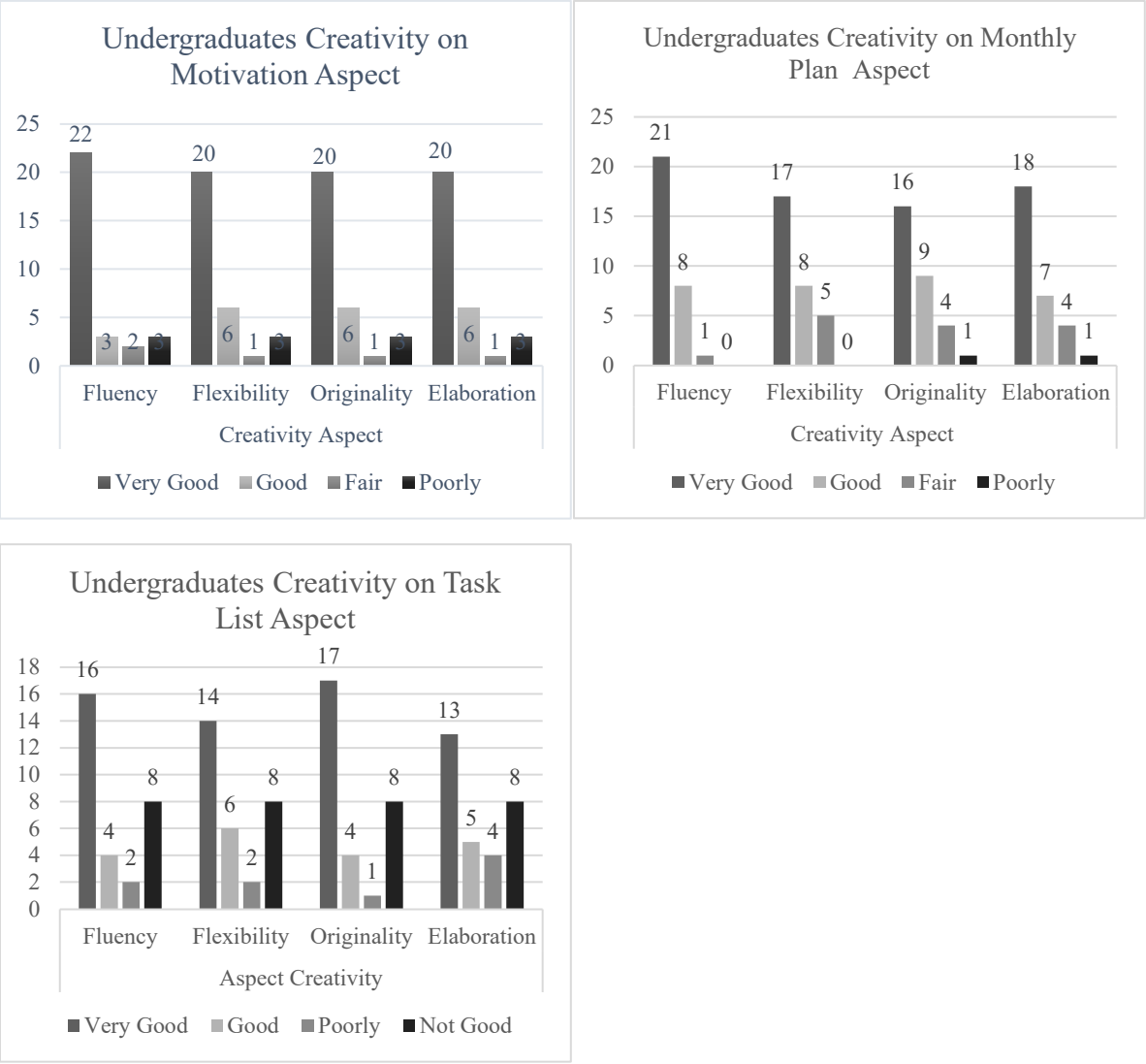

Figure 2. Distribution of the Number of Students Who Obtained the Categories of 'Very Good', 'Good', 'Fair', Poorly and 'Not Good' in Creativity Aspects Seen from Writing Course Schedule, Task List and Monthly Plan in Bullet Journaling

In writing a monthly plan, students make a schedule of academic activities such as reading books and journals, discussions with friends/lecturers/teachers, visiting the library, and doing assignments. Based on the data, all these activities can be completed by students smoothly, varied, original and precisely. So the creativity achievements are in the very good category. In accordance with the findings of Borodina, T., Sibgatullina, A., &Gizatullina, A, that routine activities such as reading literature, especially foreign languages and analyzing and interpreting the reading [8], can improve creative thinking abilities. Furthermore, O'Byrne, *et., al*., stated that "Creative teachers are teachers who are able to find new ways to solve professional problems, answer students' personality needs, are creatively motivated and have the ability to provide solutions without limitations".[9]

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Therefore, Unimed's biology education study program, which is producing future biology teachers, can create an academic environment that facilitates students to increase their creativity by providing study journals as non-standard assignments in their work. Swanzy-Impraim, E., *et., al*., states that Learning and teaching experiences during teacher education or lectures can shape and produce policies and practices in the world of work that can produce creativity.[10]

Conclusion

The conclusion of this research is that the level of creativity of final year students in the biology education study program through Bullet Journal writing is in the 'Good' category.
For bullet journal components such as writing motivational sentences, task lists and monthly plans, the highest number of students received the Very Good category in almost all aspects/dimensions of creativity, while for other components such as semester plans and lecture schedules the highest number of students were in the 'Good' category. However, further research needs to be carried out to see the consistency of bullet journal writing in measuring students' creativity levels

Acknowledgments

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Development of student worksheets based on development of student worksheets based on case methods and time-based project in plant morphology courses

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Abstract. *This research aimed to produce Student Worksheets based on case methods and team based project in the Plant Morphology course, which meet feasibility based on material aspects, learning aspects, graphic design, and based on responses from lecturers and students. Student worksheets were developed using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The subjects in this research consist of material expert validators, learning expert validators, lecturers in the Plant Morphology course, and Biology students in the odd semester of the 2023-2024 academic year, while the research objects were student worksheets based on case methods and team based projects in the Plant Morphology course. Based on analysis results of the achievement of the 7th Main Performance Indicator for State Universities (IKU-PTN) and curriculum analysis on KKNI level 6 learning achievements, it is required to develop a learning tool that can accommodate case methods and team based project learning activities. The learning tool that contains activities during the learning process is the student worksheets. Student worksheets based on the case methods and team based projects, also contain 6 KKNI tasks really needed to realize the achievement of the 7th IKU-PTN, namely the creation of collaborative and participatory classes, and at the same time can realize learning achievements at level 6 of the KKNI. The Student Worksheets developed is used for learning in the Plant Morphology course. The main material in plant morphology is the morphology of roots, stems, leaves, flowers, fruit, and seeds, as well as the morphology of modified plant parts from the main plant organs. According to material experts and learning experts, student worksheets based*

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on case method and team based project is very suitable for use in learning Plant Morphology courses and according to design experts is suitable. Implementation of student worksheets based on case methods ands team based projects in the Plant Morphology course can develop the character of collaborative and participatory learning.

Keywords: student worksheets, case methods, team base project

Introduction

The Directorate General of Higher Education has three main tasks in the field of higher education, namely: 1) improving the quality and relevance of higher education; 2) strengthening the quality of lecturers and educational staff; and 3) increasing access to higher education. These three tasks are contained in the Independent Campus Learning Policy, the implementation of it outlined in the Minister of Education and Culture Decree Number 3/M/2021 concerning Main Performance Indicators for State Universities (IKU-PTN). In the Director General of Higher Education, it is stated there are eight Main Performance Indicators stipulated in the Minister of Education and Culture Decree, including the 7th Main Performance Indicator (IKU), namely collaborative and participatory classes [1]. In the technical explanation of the 7th IKU there are case solving methods and team base projects as methods that must be applied in classroom learning to create collaborative and participatory classes.

The gradation of learning outcomes at level 6 of the KKNI (undergraduate level) includes students' ability to apply, study, create designs, utilize science and technology, also solve problems. Description of Level 6 Learning Achievements in KKNI is being able to apply the field of expertise and utilize science and technology in their field in solving problems and being able to adapt to the face situations. Master the theoretical concepts of a particular field of knowledge in general and the theoretical concepts of a specific part of that field of knowledge in depth, and be able to formulate procedural problem solving. Able to make the right decisions based on information and data analysis, and able to provide guidance in choosing various alternative solutions independently and in groups. Responsible for own work and can be given responsibility for achieving the organization's work results. Implementation of the 7th IKU stipulated in the Minister of Education and Culture Decree above can accommodate most of the learning outcomes at level 6 of the KKNI.

Student worksheets are teaching materials that contain a summary of the material and instructions for implementing learning tasks that students must complete, both theoretical and practical, which refer to the specified learning outcomes. Student worksheets used in teaching and learning activities can make students active in the teaching and learning process, help students in developing concepts, train students in finding and developing knowledge, add information about the concepts being studied through systematic learning activities. Student worksheets can build students' overall abilities in various aspects such as independent learning, reasoning, ability to investigate, and solve problems [2]. Through the use of student worksheets in learning, apart from improving skills, it can also foster students' creativity in thinking and acting.

Student worksheets that contain clear objectives and work procedures that with specified methods can make lectures more effective and efficient because by using student worksheets, students can be guided to study independently. Rahmi et al. stated that student worksheets can make students active in learning because student worksheets contain work steps that involve students, so they can solve a problem without complete assistance from

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the lecturer, students do not have to wait for the lecturer to present the material for understand lecture material [3].

Case method is a problem solving learning method [4], students are directed to be able to solve a problem. Case Method is a discussion-based participatory learning method for solving cases or problems. Applying this method can help students hone and improve critical thinking skills for solving problems, communication skills, collaboration and creativity. The case method is a constructivist learning method, a learning method that provides students with the opportunity to build their own knowledge

Team base project learning method or project based learning is a learning method that involves learning participants in designing, making and displaying products to solve a problem. The role of the instructor/lecturer in this learning method is as a facilitator/intermediary to obtain optimal results in accordance with the imagination, creativity and innovation of the learning participants. Like the case method, team based projects are also constructivist. Murfiah stated that project based learning is a learning method that uses problems as the first step in collecting and integrating new knowledge based on experience in carrying out real activities [5].

In learning by applying the case method and team-based project, students are encouraged to carry out science process skills such as analyzing, predicting, finding, evaluating, designing, concluding, and collaborating. These science process skills can form students' characters who are skilled, creative, innovative, cooperative and participative and will form collaborative classes because learning is carried out in teams or groups.

Plant Morphology is a course that studies the morphological structure of plants, especially Spermatophyta. That is including the morphology of roots, stems, leaves, flowers, fruit and seeds as well as modified organs of the main plant organs. The study of root morphology includes tap root and fiber root systems, which has variations in its morphological characteristics. Study of stem morphology includes type, shape, direction of stem growth and stem branching. The study of leaf morphology includes leaf type, leaf structure, variations in tip, variation base, leaf edge and phyllotaxis. The study of flower morphology includes flower components, flower types seen from several aspects and flower formulas. The study of fruit and seed morphology includes types based on several aspects [6]. Student worksheets can be used to help students master the substance/material in plant morphology through discovery and proof as well as developing a concept by following the procedures in the student worksheets.

From the description above, achieving the 7th IKU, namely creating collaborative and participatory classes through the case method and team base project learning methods, can be done by providing and using student worksheets that are designed according to the characteristics and syntax of the case method and team base project. It is assumed that this student worksheet can be used to accelerate the achievement of IKU-PTN targets.

This research can contribute to the provision of case method and team based project student worksheets in the Plant Morphology course and further contribute to the realization of collaborative and participatory classes as mandated in the Ministry of Education and Culture number 3/M/2021.

Methodology

The research was conducted at the Biology Department, FMIPA, Medan State University, Jl. Willem Iskandar Pasar V Medan. This research is product development research. The product developed is a Student Worksheet for the Plant Morphology course. Student worksheets were developed using the ADDIE development model which consists of five

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stages, namely analyze, design, development, implementation and evaluation [7]. The schematic can be seen in the following image.

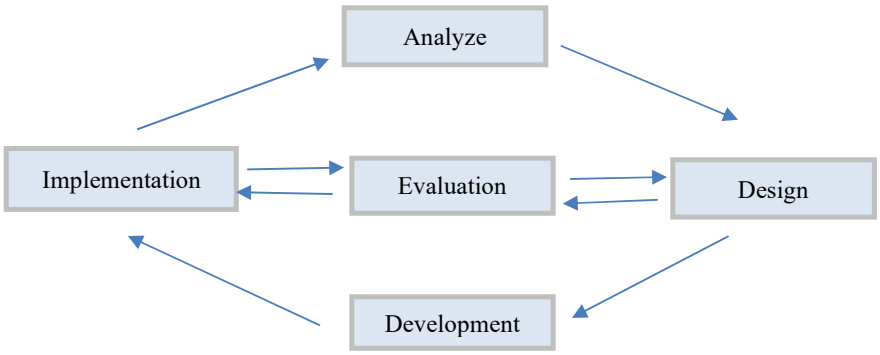

Figure 1. ADDIE Development Model Stages [7]

The subjects in this research were material expert validators, learning expert validators, lecturers in the Plant Morphology course and Biology students in the odd semester of the 2023-2024 Academic Year, while the research objects were student worksheet based on case method and team-based projects method in the Plant Morphology course.

Analysis of the feasibility of student worksheets was carried out descriptively quantitatively, to show the quality of student worksheets based on data obtained from the results of filling out questionnaires by a team of validation experts, responses from lecturers and students. The data obtained is in the form of validation expert assessments using a scale of 1 to 4, with the information (1) not feasible, (2) deficient, (3) feasible, and (4) very feasible. The response scale for lecturers and students is on a scale of 1 to 4 with the following information: (1) strongly disagree, (2) disagree, (3) agree and (4) strongly agree.

To determine the level of feasibility and eligibility criteria for teaching materials/student worksheets, use the modified formula and criteria from Sugiyono [8].

For the appropriateness level of student worksheet books, the following formula is used:

$$\text{Score Percentage} = \frac{Number\ of\ Indicator\ per\ Category}{Number\ of\ Total\ Category\ Indicators} \times 100\%$$

Table 1. Student Worksheet Eligibility Criteria

Not Fasible	< 65
Deficient	65-74
Feasible	75 -84
Veri Feasible	85 – 100

Tabel 2. Criteria for lectures and student responses to the student worksheet

Strongly Disagree	< 65
Disagree	65-74
Agree	75 -84
Strongly Agree	85 – 100

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Results and Discussion

Analyze.

Analysis of IKU-PTN Achievement and Curriculum

Main Performance Indicators for State Universities (IKU-PTN) are contained in Kepmendikbud Number 03/M/2021. There are eight Main Performance Indicators (IKU) stipulated in the government policy, including the 7th IKU, namely the collaborative and participatory class. In the 7th IKU technical explanation, it is stated that the case method and team base project are methods that must be applied in classroom learning to create collaborative and participatory classes. The 7th IKU is the embodiment of Learning Achievements at level 6 (Undergraduate level) of the Indonesian National Qualifications Framework (KKNI) which is a reference in developing/preparing the curriculum in Higher Education.

Learning outcomes at level 6 of the KKNI are students' ability to apply, study, create designs, utilize science and technology, and also solve problems. Description of Level 6 learning achievement in KKNI is being able to apply one's field of expertise and utilize science and technology in one's field in solving problems and being able to adapt to the situations faced. Master the theoretical concepts of a particular field of knowledge in general and the theoretical concepts of a specific part of that field of knowledge in depth, and be able to formulate procedural problem solving. Able to make the right decisions based on information and data analysis, and able to provide guidance in choosing various alternative solutions independently and in groups. Responsible for one's own work and can be given responsibility for achieving the organization's work results.

In order to achieve the 7th IKU which is meaningful and also to realize Learning Achievements at level 6 of the KKNI, it is necessary to develop a learning tool that accommodates case method and team based project learning activities, which is then hoped to create collaborative and participatory classes. Apart from the Semester Learning Plan, the learning tools that need to be developed to realize the achievement of the 7th IKU are student worksheets that are designed according to the characteristics or syntax of the case method and team base project**.**

Needs Analysis of Student Worksheet

Student worksheets are teaching materials that contain summaries of material and instructions for implementing learning tasks that students must complete, both theoretical and practical, which refer to specified learning outcomes. Student worksheets used in teaching and learning activities can make students active in the teaching and learning process, help students find and develop concepts, train students in finding and proving a material concept. Using student worksheets in learning can improving skills, and foster students' creativity in thinking and doing. With student worksheets, learning activities in class can be more focused, students can carry out learning activities independently by following the activity steps in the student worksheets.

Student Worksheet which contains tasks to realize KKNI level 6 Learning Achievements (undergraduate level) namely Critical Book Report (CBR), Critical Journal Review (CJR), Mini Research, Idea Engineering, Project and Routine Assignments as well as student worksheets based on case methods and team based projects are really needed to realize active learning activities, so that collaborative and participatory classes can be created.

Design

At this stage, student worksheet development is carried out by designing student worksheet based on case method and team based project, which is used for learning in Plant

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Morphology courses. The main material in plant morphology is the morphology of roots, stems, leaves, flowers, fruit and seeds as well as the morphology of modified plant parts from the main plant organs. Worksheets is designed according to the character or syntax in the case method and team base project.

Develop

This stage starts from validating student worksheets by material experts, learning experts, and design experts. From the validation results, the student worksheets are revised according to the validator's suggestions. The things that are revised are to complete and deepen the study of several materials in several chapters in student worksheets. Apart from that, it also adapts theory so that it can be used as a reference in working on student worksheets. Improve several work procedures in student worksheets, so that it conform to the syntax of established methods such as the case method and team base project. The validation results on the material aspect were 88.9% with very feasible criteria. The validation results on the learning aspect were 91.2% with very feasible criteria. The validation results for the student worksheet design aspect were 83.8% with feasible criteria.

Implementation* dan *Evaluation

At this stage, revised student worksheets are given to lecturers and students to be used in studying the Plant Morphology course. From the lecturer's response, an assessment of 88.3% was obtained and the student response was 85% with the criteria of strongly agreeing to use student worksheet based on case method and team based project in learning because they can make students work collaboratively and participatively, really helping students master the concepts of plant morphology material and in improving psychomotor abilities in determining plant morphological characters. In line with the research results of Febriani [9] , student worksheets can increase student activity in learning, which has implications for students' better understanding of the substance of the material.

Conclusion

Student Worksheets are very necessary for learning activities, including in studying Plant Morphology courses. Student worksheets that are designed according to the objectives will really help lecturers and students in carrying out learning activities. Student worksheets based on the case method and team base project are designed according to the stages and characteristics of the case method and team base project, especially the work procedures. The development of student worksheets based on the case method and team base project in the Plant Morphology course is very useful and necessary in helping students to discover and develop material concepts, train students in proving and discovering material concepts, improve students' skills (psychomotor), foster students' creativity in thinking and action. The use of student worksheets makes learning activities more focused, students can carry out learning activities independently by following the activity steps in the student worksheets. Student worksheets based on these two methods can create active learning, so that collaborative and participatory learning can be realized.

Acknowledgments

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Online Diagnostic Assesment in Support of Differentiated Learning

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Abstract. *To assess the characteristics, conditions, strengths, and weaknesses of students' learning styles, an initial evaluation is required. By conducting this assessment, teachers are able to better understand what is being taught, how to manage the learning, and how successful they are as teachers overall. The aims of this study: to create e-assessment diagnostics to aid in differentiating learning. Research and development (R&D) is the term used to describe this kind of study, which is also known as Thiagarajan's 4D model. The Define, Design, Develop, and Disseminate stages are part of this approach. Data was collected in phases, with each stage involving the collection of expert validation, practicality testing, and diagnostic assessment data. Products are created by leveraging the Laravel framework and PHP programming. A database has been built in the program to manage specific data. The main focus in the e-assessment is on non-cognitive diagnostic evaluations such as learning styles, motivation, and student family conditions, which are subsequently utilized to construct student-centered differentiated learning.*

Keywords : E-assesment, diagnostic, differentiated learning, learning style, evaluation

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Introduction

Indonesia has been using Kurikulum Merdeka since 2021. Implementing student-centered learning is one of the interventions in the context of recovering from the COVID-19 pandemic, and it is thought to be quite crucial [1]. Students are expected to be autonomous in their learning process, take the initiative to identify their own learning needs, locate information sources to meet those needs, and develop and present their knowledge based on those needs and the sources they locate when applying the student-centered concept[2].

Each student has highly different and specific learning demands [3]. Learning styles (such as auditory, visual, or kinesthetic), academic ability (high, medium, low), learning orientation (mastery, performance approach, performance avoidance), motivation (high, medium, low), self-efficacy (high, medium, low), interest (such as in a particular subject, especially mathematics, language, or science), personality (e.g. as introvert or extrovert), and socioeconomic status/SSE (high, medium, low SSE) are some instances of the uniqueness and diversity[4] [5].

In order to acknowledge this diversity and individuality, schools have to conduct a diagnostic assessment linked to this aspect. This diagnostic assessment aids teachers in identifying the content being taught, the best way to manage learning, and the effectiveness of their instruction; however, teachers are not prepared to perform this assessment in terms of their understanding and readiness [6]. Teachers still need socialization and training to learn more about this assessment[7].

Teachers will require the assessment findings in order to create differentiated instruction [8]. The differentiated learning is instruction that meets each student's unique requirements, respects their uniqueness, and is accessible to all [9]. Because every student is particular and grows up in a distinct environment and culture depending on where they reside, it is essential to always consider the distinctive qualities of each individual student. Furthermore, it ensure that each student in the class is aware of the availability of support at all stages through the process [10].

The learning process should be moved to an online platform in order to accommodate 21st century learning, which includes the evaluation of learning objectives [11]. Because they only use paper and portfolios, the assessment findings are frequently misplaced or forgotten. There isn't a database containing the current assessment results at the school. According to the above explanation, a web-based diagnostic assessment development system is required. It should be easy for students to finalized, show results immediately, and be able to be prevented as a school database. Therefore, the results can be used for the learning process while offering feedback on the student's current condition.

It is intended that by using this e-assessment, teachers will be able to create learning sequences based on the developmental phases of their pupils. According to research [12], all science teachers used diagnostic assessments during the pandemic. This is in accordance with the Decree of the Minister of Education and Culture of the Republic of Indonesia, 2020, which specifies that "during this pandemic, before learning, teachers are encouraged to carry out diagnostic assessments.". However, despite conducting this diagnostic assessment, the teacher did not use differentiated learning to its full potential.

Method

Using the Thiagarajan 4-D development paradigm (four-D paradigm), this study engaged research and development (R&D). Definition, design, development, and dissemination were the phases[13]. Three analyses were conducted at the define stage: curriculum, needs, and problem analyses. Designing learning objectives initial page, tests and test results as well as conclusions and recommendations. Throughout the development stage, the e-assesment was reviewed by

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experts in content, language, and content. The validation results were utilized to assess the level of feasibility applying an equation adopted from.

$$P = \frac{\Sigma}{N} \times 100\%$$

Table 1. The Feasibility of Validation Criteria for the Teaching Materials

Criteria	Interval Percentage
Very Less Feasible	<21%
Less Feasible	21% -40%
Quite Feasible	41% - 60%
Feasible	61% - 80%
Very Feasible	81% - 100%

At the dissemination stage, e-assesment was implemented to student. Based on the responds of teachers and students, a practicality test was conducted. The fishbone figure below provides further information about this research plan see. fig.1.

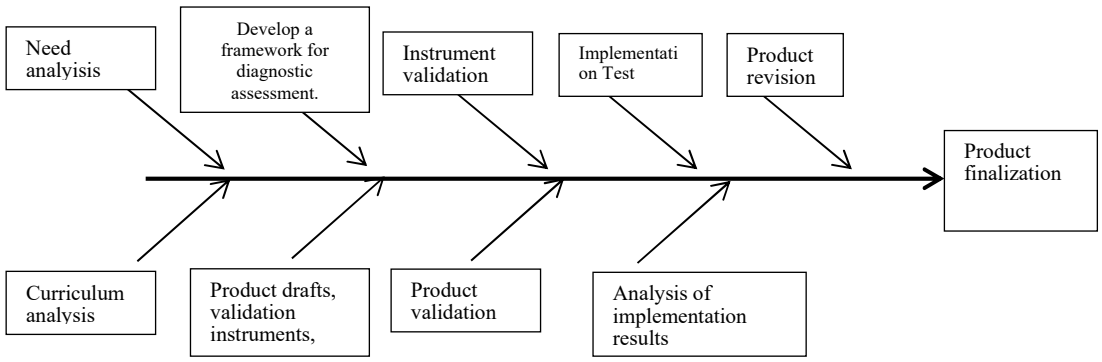

Figure 1. Fishbone Diagram for Diagnostic E-Assessment Development Research

Result and Discussion

Defining Stage (Define)

At this stage, three analyzes are performed curriculum analysis, needs analysis, and problem analysis. This study is in accordance with the aims of the independent curriculum, which emphasizes learning based on the circumstances of students. As a result, in order to achieve these objectives, an initial diagnosis of students is required. Teachers will need the results of this diagnostic evaluation to construct differentiated learning later on. Differentiated learning is defined as learning that accommodates all student differences, is accessible to all, and meets the needs of each individual [14]. Because each student grows up in a different environment and culture depending on the geographical conditions in which they live, the variety of each individual student must always be considered.

Designing Stage (Design)

At this stage, prepare the components of the test instrument that will be usedsuch as as learning styles, motivation, and student family conditions, which are subsequently utilized to construct student-centered differentiated learning. At this product design stage, the initial product was developed in the form of an e-assessment diagnostic using the web. Products are created by

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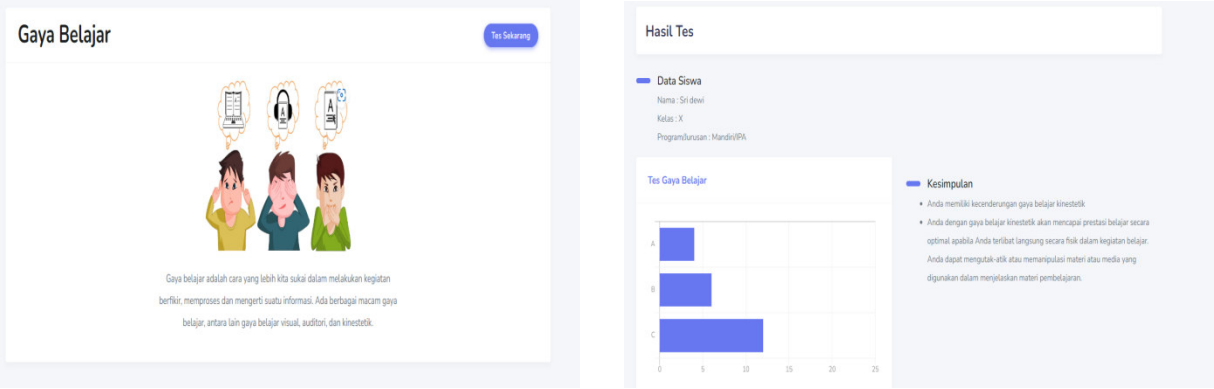
leveraging the Laravel framework and PHP programming. A database has been built in the program to manage specific data. The systematics of the designed assessment consists of: initial page, tests and test results as well as conclusions and recommendations.

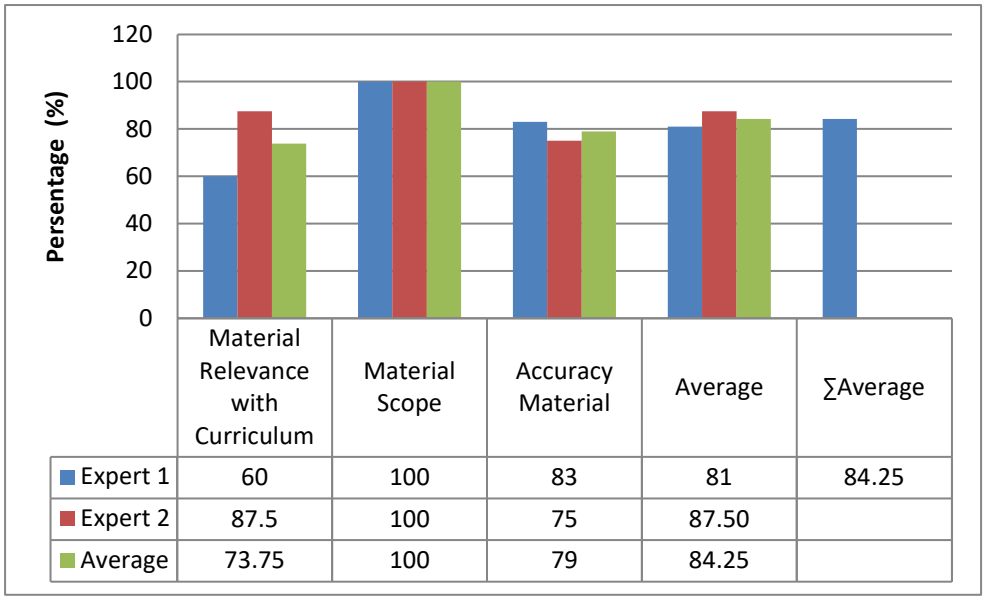


(a) (b)

Figure 2. A designed page on online diagnostic assessment; a) Initial Page b)Test Result

Development Stage (Develop)

Following completion of the online diagnostic assessment, it would be validated by two subject experts, two language experts, and two learning media experts. Validation would be repeated until the product was found to be valid. The validation results would be examined based on the questionnaire filled out by experts. The results of the content expert's evaluation were presented in fig. 3, language experts in fig. 4, and learning media experts in fig. 5.



	Material Relevance with Curriculum	Material Scope	Accuracy Material	Average	∑Average
Expert 1	60	100	83	81	84.25
Expert 2	87.5	100	75	87.50	
Average	73.75	100	79	84.25	

Figure 3. Content Expert Interpretation of Bar Graph

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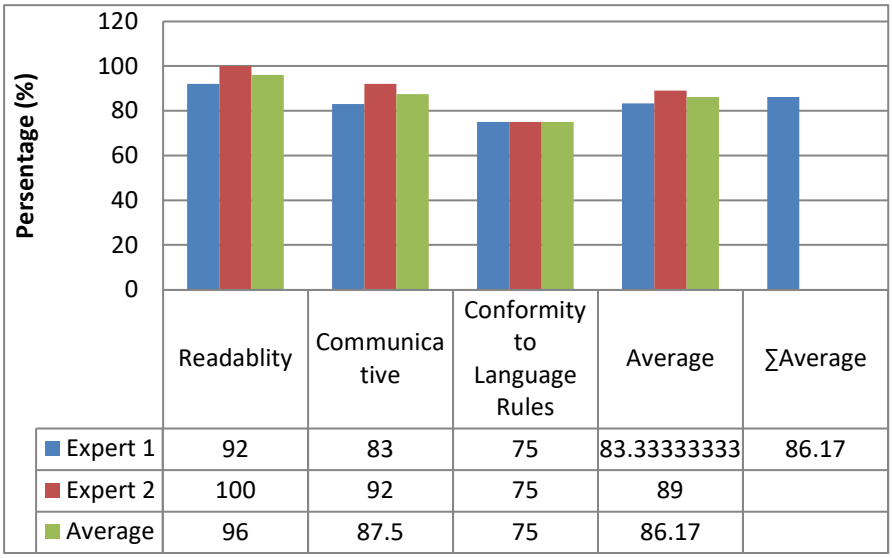
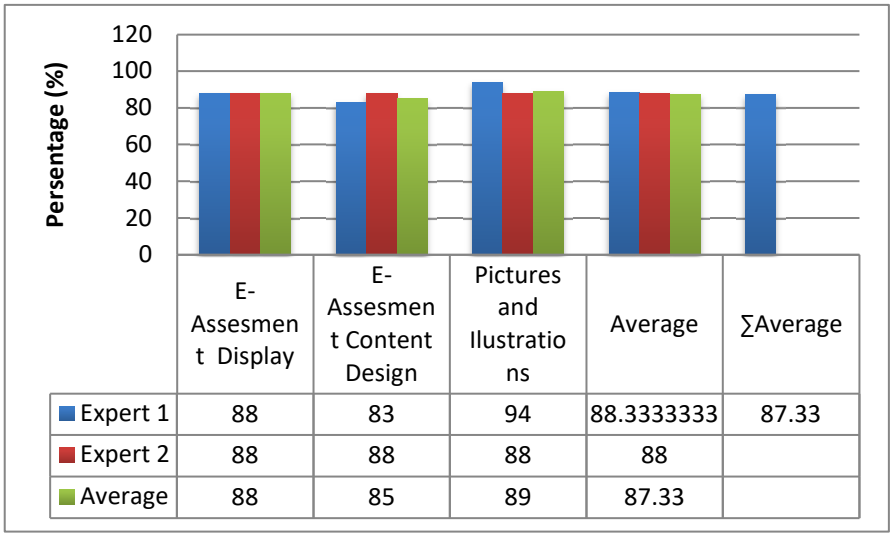


	Readablity	Communicative	Conformity to Language Rules	Average	∑Average
Expert 1	92	83	75	83.33333333	86.17
Expert 2	100	92	75	89	
Average	96	87.5	75	86.17	

Figure 4. Language Expert Interpretation of Bar Graph



	E-Assesment Display	E-Assesment Content Design	Pictures and Ilustrations	Average	∑Average
Expert 1	88	83	94	88.3333333	87.33
Expert 2	88	88	88	88	
Average	88	85	89	87.33	

Figure 5. Learning Media Expert Interpretation of Bar Graph

Based on the results of content expert validation, the online diagnostic assessment scored 84.25% with extremely appropriate criteria. The content of this e-assessment is fairly relevant and in line with the achievements to be measured. According to the language expert validation results, e-assessment was 86.17% with extremely feasible criteria. Clear terminology is required in the preparation of this e-assessment to avoid misconceptions when filling out the instrument. According to the results of learning media expert validation, e-assessment was 87.33% with extremely suitable criteria. According to media experts, the page generated is in accordance with the objectives of the product being developed, but it is critical to give attention to the appearance of the web page to make it more appealing.

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Disseminating Stage (Disseminate)

The dissemination process was completed to ensure that the finished output was accepted by users, whether they were individuals, groups, or systems. A practicality test was applied to assess the current stage. With incredibly good criteria, the student response rate to the used e-book was 84.25%. The lecture responses were 77,05% with good criteria. As a result, students enrolled in a learning media course use the e-assessment frequently.

Conclusion

The main focus in the e-assessment is on non-cognitive diagnostic evaluations such as learning styles, motivation, and student family conditions. Products are created by leveraging the Laravel framework and PHP programming. A database has been built in the program to manage specific data. Creating this online diagnostic had resulted that was very feasible to implemented as learning media by content expert, language expert, and learning media experts. In the future, we intend to conduct a survey among our students to assess the usability of our e-assessment.

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Phytochemical screening and antibacterial activity test of lichen extract *Usnea barbata* against *Bacillus cereus* & *Escherichia coli*

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Abstract. *Lichen is one of the organisms with a high biodiversity level and contains secondary metabolites that are useful as antibacterials. This study aims to determine the secondary metabolite compounds and antibacterial activity of Usnea barbata lichen extract in inhibiting the growth of Bacillus cereus and Escherichia coli bacteria. Usnea barbata extract was prepared by maceration method using 96% ethanol solvent (1:10). Based on phytochemical screening, the ethanol extract of Usnea barbata lichen contains alkaloid, flavonoid, saponin, tannin, and triterpenoid compounds. Antibacterial activity was tested using the disc diffusion method with six treatments (2.5%, 5%, 10%, 20%, negative control with sterile distilled water, and positive control with 100 mg/mL chloramphenicol) with three repetitions. The data obtained was the average diameter of the inhibition zone. In the treatment of the antibacterial activity of Usnea barbata lichen extract against the growth of Bacillus cereus bacteria, the average diameter of the positive control inhibition zone*

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was 28.1 ± 0.95 mm and 7.83 ± 0.87 mm; 9.43 ± 0.15 mm; 10.36 ± 0.47 mm; and 12.33 ± 0.41 mm from the concentration of Usnea barbata lichen extract from the smallest to the largest concentration. The treatment of antibacterial activity of Usnea barbata lichen extract against Escherichia coli growth obtained the average diameter of the positive control inhibition zone of 30.83 ± 0.15 mm and 7.16 ± 0.28 mm; 7.66 ± 0.15 mm; 8.33 ± 0.15 mm; and 10.73 ± 0.15 mm from the concentration of Usnea barbata lichen extract from the smallest to the largest concentration. Based on these results, it is known that the most effective concentration of Usnea barbata lichen extract, which has the largest inhibition zone diameter, is 20% concentration in inhibiting the growth of the two bacteria.

Keyword: Usnea barbata, antibacterial, Bacillus cereus, Escherichia coli, secondary metabolite

Introduction

Indonesia is a country with a high level of biodiversity, which serves as the basis for its exploration and discovery of various natural materials that are still pure and not widely known or utilized by the general public. In Indonesia, lichen is one of the organisms with a relatively high level of biodiversity, reaching approximately 17,000 species and possibly around 100,000 different species of lichen worldwide.[1].

Lichen is a mutualistic symbiosis between fungi and algae or cyanobacteria. The fungi provide a protective habitat or ecological niche for the algae, while the algae provide organic compounds or photosynthetic products and vitamins for the fungi. These symbiotic relationships have the ability to merge and form a thallus, making them physiologically and morphologically a new individual entity[2]. Lichens live as epiphytes on trees, on rocks, or various other substrates and do not require complex living conditions. They are also resilient to water deficiencies. Lichens can be found from the seashore to mountains[3].

The ability of lichens to survive in hot, cold, and dry conditions is undoubtedly attributed to the secondary metabolites they produce, which enable them to protect themselves from the environment, microbes, predators, and competitors[4]. Lichens can be considered as a source of natural materials for discovering new bioactive compounds, either directly from their secondary metabolites or through chemical modifications using isolated natural compounds[5].

The antibacterial properties of lichen metabolites were first investigated by Burkholder in 1944, who showed that 27 out of 42 lichen extracts from different species were active against *Bacillus subtilis* and *Staphylococcus aureus*[6]. In a study conducted by Amalia and Trimulyona [7], the extract of*Usnea subfloridana* lichen was found to inhibit the growth of *Escherichia coli* and *Staphylococcus aureus* bacteria[7]. Based on these studies, it is known that lichen extracts have the ability to inhibit and kill pathogenic bacteria.

Some examples of pathogenic bacteria are *B. cereus* and *E. coli*. *B. cereus* can produce exotoxins that cause diarrhea. *B. cereus* ranked second as the cause of food poisoning outbreaks from 2007 to 2011 in Indonesia and is a potential cause of foodborne illness syndrome often associated with diarrhea[8]. In *E. coli*, certain strains of this bacteria frequently cause diarrhea, ranging from mild cases to severe cases that can lead to death, with a mortality rate of 20% among over 10 million children under the age of 5 each year[9]. Infections caused by bacteria can be treated with the use of antibiotics. However, the irrational use of antibiotics has led to the development of resistance by microbes to many antibiotics, creating a serious clinical problem in the treatment of infectious diseases[10]. *Escherichia coli* bacteria, particularly the O157:H7 strain, have become resistant to several

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antibiotics, including amoxicillin, streptomycin, methicillin, penicillin, and others[11]. Meanwhile, *Bacillus cereus* bacteria have developed resistance to erythromycin, carbapenem, and tetracycline antibiotics, making empirical treatment selection more challenging[12].

Therefore, the management of these two types of bacteria is crucial. Natural materials available in nature can be utilized as an alternative approach. Lichens can be a potential natural resource that can be harnessed for this purpose. The appropriate utilization of natural materials can provide effective treatment while minimizing the side effects. Screening the antibacterial activity of natural substances against various bacteria can serve as an initial step in the research and development of antibacterial agents. Screening can be focused on determining the activity of specific natural substances against bacteria.

Based on this background, a study was conducted on the phytochemical screening and antibacterial activity test of *Usnea barbata* lichen extract against *Bacillus cereus* and *Escherichia coli* bacteria. Phytochemical screening was performed to determine the groups of metabolite compounds present in the ethanol extract of *Usnea barbata* lichen, including alkaloids, flavonoids, saponins, triterpenoids, and tannins. The antibacterial activity test of the lichen extract was conducted using the disc diffusion method.

Methods

Time and place of research

The research was conducted from March to May 2021. The extraction of *Usnea barbata* lichen and phytochemical screening were carried out at the Phytochemistry Laboratory, Faculty of Pharmacy, University of Sumatera Utara. The antibacterial activity testing was performed at the Medan Regional Health Laboratory.

Phytochemical Screening

Phytochemical screening was conducted to identify secondary metabolites in the *Usnea barbata* lichen extract. The tested qualitative secondary metabolites included alkaloids, flavonoids, saponins, triterpenoids, and tannins. Positive results (+) were indicated by color changes, precipitate formation, or foam formation after adding reagents to the test extract. Negative results (-) were indicated by no color changes, precipitate formation, or foam formation after adding reagents to the test extract.

Antibacterial Activity Testing

The antibacterial activity testing was performed using the disk diffusion method. Approximately 15 mL of MHA (Mueller Hinton Agar) medium was poured into sterile petri dishes and allowed to solidify. A sterile cotton swab was dipped into the *Bacillus cereus* bacterial suspension and evenly spread across the agar surface in the petri dish. Subsequently, 5 mm diameter paper disks soaked in six different treatments were placed on the solidified MHA medium that had been inoculated with the bacterial suspension. The treatments included a negative control (sterile distilled water), a positive control (chloramphenicol 100 mg/mL), and extract concentrations of 2.5%, 5%, 10%, and 20%. The petri dishes were then inverted and incubated at 37°C for 24 hours. After 24 hours, the diameter of the inhibition zone (clear zone) formed on the medium was observed. The inhibition zone was measured using a caliper to determine the bacterial activity. The experiment was repeated three times, and the same procedure was carried out for

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Escherichia coli. Data analysis was conducted descriptively and presented in tables and graphs.

Results and Discussion

The ethanolic extract of *Usnea barbata* lichen yielded a concentrated extract of 45.88g with a yield value of 11.47%. The ethanolic extract of *Usnea barbata* lichen had a brownish color, thick consistency, and a distinctive odor. Phytochemical screening is a preliminary stage of research aimed at providing an overview of the compound groups present in the sample under investigation, in this case, the ethanolic extract of *Usnea barbata* lichen. Based on the research results, it was found that the ethanolic extract of *Usnea barbata* lichen contains the following groups of secondary metabolite compounds alkaloids, flavonoids, saponins, tannins, and triterpenoids (Table 1).

Table 1. Phytochemical screening test results of *Usnea barbata* lichen ethanol extract

No	Secondary metabolite	Reagent	Result	Information
1	Alkaloids	Dragendroff	(-)	No red/orange precipitate is formed
		Bouchardat	(+)	A brown precipitate forms
		Mayer	(+)	A white precipitate is formed
2	Flavonoids	Mg Powder + Amyl Alcohol + HClp	(+)	Forms a deep orange color
3	Saponin	Hot Water	(+)	Form a stable 1 cm high foam
4	Tannin	$FeCl_3$	(+)	A blackish blue color is formed
5	Triterpenoids/Steroid	Lieberman-Bourchat	(+)	A purple red color is formed

The alkaloid compound testing was performed using three reagents: Dragendorff's reagent, Bouchardat's reagent, and Mayer's reagent. The alkaloid compound testing showed positive results indicated by the formation of precipitates or turbidity in at least two out of three experiments. Specifically, a brown precipitate formed when reacting with Bouchardat's reagent, a white precipitate formed when reacting with Mayer's reagent, and no red or orange precipitate formed when reacting with Dragendorff's reagent, indicating a negative result. This testing only resulted in a clear brown solution upon the addition of Dragendorff's reagent.

The flavonoid compound testing showed positive results indicated by the formation of two layers in the solution, with the top layer (amyl alcohol) changing color to dark orange after adding Mg powder and concentrated HCl. The saponin testing resulted in a positive result with the formation of a 1 cm foam that lasted for approximately 10 minutes and did not disappear after adding 1 drop of 2 N HCl.The examination of the sample showed the presence of tannin compounds in the *Usnea barbata* extract, indicated by a color change to dark blue-black when adding 1% FeCl3 to the diluted filtrate. The triterpenoid testing also showed a positive result, indicated by the change in color of the evaporated filtrate when treated with Lieberman-Buchard reagent, turning into a reddish-purple color.

The phytochemical screening results of the ethanolic extract of *Usnea barbata* lichen are consistent with the study conducted by Hazimi [13] on the phytochemical screening of

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several medicinal plants. The study states that *Usnea barbata* (lichen) tested positive for the presence of secondary metabolite compounds, such as flavonoids, terpenoids, saponins, and tannins. These active compound groups, including flavonoids, alkaloids, saponins, and tannins, present in the lichen extract, are known to possess antibacterial properties.

Table 2. Antibacterial Activity Test Results of *Usnea barbata* Lichen Ethanol Extract Against *Bacillus cereus* Bacteria

Concentration	Diameter of Inhibitory Growth			Mean±SD	Potency
	1	2	3		
2,5 %	7.1	7.6	8.8	7.83 ± 0.87	Moderate
5 %	9.4	9.3	9.6	9.43 ± 0.15	Moderate
10 %	10.0	10.2	10.9	10.36 ± 0.47	Strong
20 %	12.0	12.8	12.2	12.33 ± 0.41	Strong
Kontrol (+)	28.0	29.1	27.2	28.1 ± 0.95	Very strong
Kontrol (-)	-	-	-	-	-

Table3. Activity Test Results of *Usnea barbata* Extract Against *Escherichia coli* Bacteria

Concentration	Diameter of Inhibitory Growth			Mean±SD	Potency
	1	2	3		
2.5 %	7.0	7.5	7.0	7.16 ± 0.28	Moderate
5 %	7.7	7.8	7.5	7.66 ± 0.15	Moderate
10 %	8.2	8.5	8.3	8.33 ± 0.15	Moderate
20 %	10.7	10.9	10.6	10.73 ± 0.15	Strong
Kontrol (+)	30.7	31	30.8	30.83 ± 0.15	Very Strong
Kontrol (-)	-	-	-	-	-

Based on the obtained data, it shows that the ethanol extract of *Usnea barbata* lichen has potential as an antibacterial against `*Bacillus cereus* and *Escherichia coli* bacteria. The highest bacterial inhibition ability was observed at a concentration of 20%, with respective zone of inhibition diameters of 12.33 mm and 10.73 mm, which are considered strong. At a concentration of 10%, the average zone of inhibition diameters against *Bacillus cereus* and *Escherichia coli* were 10.36 mm (strong category) and 8.33 mm (moderate category), respectively. At a concentration of 5%, the average zone of inhibition diameters were 9.43 mm (moderate category) for *Bacillus cereus* and 7.66 mm (moderate category) for *Escherichia coli*. The smallest bacterial inhibition ability was observed at a concentration of 2.5%, with zone of inhibition diameters of 7.83 mm (moderate category) for *Bacillus cereus* and 7.16 mm (moderate category) for *Escherichia coli*.

The positive control treatment using chloramphenicol antibiotic was able to inhibit the growth of *Bacillus cereus* and *Escherichia coli* bacteria, with average zone of inhibition diameters of 28.1 mm and 30.83 mm, respectively. Meanwhile, the negative control treatment showed no zone of inhibition formation for both test bacteria. This indicates that the negative control lacks the ability to inhibit the growth of *Bacillus cereus* and *Escherichia coli* bacteria.

The difference in results is due to the difference in species between the two bacteria, which affects the differences in cell wall structure, plasma membrane, and pathogenicity of the bacteria. Escherichia coli, a gram-negative bacterium, has a complex cell wall structure consisting of three layers: an outer layer, a middle layer, and an inner layer. The outer layer consists of lipoprotein, the middle layer consists of thick peptidoglycan, the inner layer

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consists of lipopolysaccharide. On the other hand, the cell wall structure of Bacillus cere, a gram-positive bacterium, is simpler and consists only of a peptidoglycan layer[14].Gram-negative bacteria have a double plasma membrane with a thickness of >80 nanometers, protected by a permeable outer membrane with a high lipid content. Gram-positive bacteria, on the other hand, have a single plasma membrane, low lipid content, a cell wall thickness of 20-80 nanometers, and the cell wall is surrounded by peptidoglycan[8].

These conditions cause Gram-positive bacteria to be more easily penetrated by antibacterial compounds, making it easier for the compounds to find targets to inhibit or interfere with their metabolism compared to the complex cell wall structure of Gram-negative bacteria. Additionally, Gram-positive bacteria have lower pathogenicity compared to Gram-negative bacteria[15].The *Usnea barbata* lichen extract is also known to contain flavonoid compounds. Flavonoids are lipophilic and can disrupt bacterial membranes. These compounds form hydrogen bonds with extracellular proteins and become soluble, resulting in the breakdown of bacterial cell walls and the release of intracellular compounds[16]. In the destruction of the cell membrane, H+ ions from phenolic compounds attack the polar groups (phosphate groups), causing phospholipid molecules to degrade into phosphoric acid, glycerol, and carboxylic acid. This condition causes the phospholipids to be unable to maintain the shape of the cell membrane, resulting in membrane leakage and the release of cytoplasm from the cell. The continuous release of cytoplasm from the cell leads to the loss of organelles and nutrients within the bacteria itself.

Disruption of the bacterial cell wall can also be caused by saponin compounds found in *Usnea barbata* lichen extract. Saponins have the ability to inhibit protein synthesis and cause damage to bacterial cell components. Protein synthesis is a vital metabolic process in bacteria that is closely related to their survival. Damaging cell components, especially DNA, RNA, and proteins, leads to total cell damage and bacterial lysis, rendering them unable to replicate[15].According to research findings, *Usnea barbata* lichen extract also contains tannins. According to Nuria[17], the antibacterial mechanism of these compounds involves inhibiting the activity of reverse transcriptase and DNA topoisomerase enzymes, preventing bacterial cell formation, inactivating microbial cell adhesins, and disrupting protein transport within the cell[18].Tannins are lipophilic compounds, making them easily bind to the cell wall, resulting in the disruption of microbial cell walls[19].

Triterpenoid compounds in *Usnea barbata* lichen extract also inhibit the growth of Bacillus cereus and Escherichia coli bacteria. These compounds can penetrate the cell walls of both gram-positive and gram-negative bacteria. Triterpenoids react with porins (transmembrane proteins) on the outer cell membrane and form strong polymer bonds, leading to porin damage. Damaged porins reduce cell wall permeability, depriving bacteria of nutrients and causing their death[20].Porin proteins are found in the outer membrane of gram-negative bacteria and are responsible for the entry of certain enzymes.

The presence of tannins and flavonoids, which are phenolic compounds, also indicates the antibacterial activity of ethanol extract from *Usnea barbata* lichen. Phenolic compounds work by denaturing cellular proteins, causing bacterial proteins to lose their biological activity. Disruption of bacterial cell permeability leads to cell lysis and bacterial death[21].
Based on the antibacterial activity testing of *Usnea barbata* lichen extract against the test bacteria, it can be observed that the average zone of inhibition or clear zone diameter produced by the extract ranges from 7.16 to 12.33 mm. This indicates that the concentrations used in this antibacterial activity testing fall into the moderate to strong category. This categorization is based on the classification by David and Stout [22], which states that a

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clear zone diameter of 10-20 mm indicates strong inhibition, a diameter of 5-10 mm indicates moderate inhibition, and a diameter of <5 mm is classified as weak inhibition[23]. In the negative control treatment using sterile distilled water, no inhibition zones were observed, indicating that adding distilled water to *Usnea barbata* extract did not affect the diameter of the inhibition zones for both test bacteria. However, in the positive control treatment using chloramphenicol 100 mg/mL, inhibition zones of 28.1 mm for B. cereus and 30.83 mm for E. coli were observed, indicating a strong growth inhibition response (inhibition zone > 20 mm). This is because chloramphenicol can inhibit microbial protein synthesis by blocking the attachment of amino acids to the peptidyl transferase site on the 50S ribosomal subunit, thereby disrupting the function of the peptidyl transferase enzyme[24].The low inhibitory potency of *Usnea barbata* extract compared to chloramphenicol is due to the fact that the extract used is a crude extract containing various active compounds, each of which has different effects on inhibiting the growth of test bacteria. This lack of synergism among the active compounds leads to a decrease in their effectiveness when mixed together[25].Additionally, the limited amount of dissolved extract also contributes to a decrease in its inhibitory activity, as the antibacterial substances present in the extract are also limited[14].

Furthermore, the results of this study show that increasing the concentration of the extract leads to larger inhibition zones on the media, with the most effective concentration being 20% in terms of producing the largest inhibition zone diameter. This is because one of the factors influencing the inhibition of microbial growth is the concentration of the antimicrobial agent. Higher concentrations result in a higher content of secondary metabolites in the extract, leading to larger inhibition zone diameters[26].

Conclusions

Based on the conducted research, it can be concluded that the ethanol extract of *Usnea barbata* lichen contains secondary metabolites such as alkaloids, flavonoids, saponins, tannins, and triterpenoids. The ethanol extract of *Usnea barbata* lichen at concentrations of 2.5%, 5%, 10%, and 20% can inhibit the growth of Bacillus cereus and Escherichia coli bacteria. The most effective concentration, which produced the largest inhibition zone diameter against Bacillus cereus and Escherichia coli bacteria, was 20%, with average inhibition zone diameters of 12.33 mm and 10.73 mm, respectively. The size of the inhibition zone increases with higher extract concentrations.

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Decoction of sikkam bark (*Bischofia javanica*) on blood glucose levels and pancreatic histopathology in alloxan-induced white rats (*Rattus norvegicus*)

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Abstract. *Diabetes was a disease characterized by hyperglycemia in individuals, resulting in progressive changes in the structure of pancreatic β cells. Alloxan was a toxic compound that could induce diabetes in experimental animals by damaging β cells in the pancreas, leading to diabetes mellitus. The bark of Bischofia javanica contained various compounds such as flavonoids, quercetin, sitosterol, phenols, and triterpenoids, which acted as antioxidants. This study aimed to investigate the effects of decoction extract of Bischofia javanica bark on body weight, blood glucose levels, and the histopathological diameter of the pancreas in aloksan-exposed white rats. The experiment employed a completely randomized design (CRD) with 5 treatments and 5 replications. The treatments consisted of a normal group (P1), a positive control group given metformin (P2), a treatment group P3 given 5% B. javanica bark decoction, a treatment group P4 given 10% DKBS, and a treatment group P5 given 15%. The study was conducted for 14 days, with decoction and metformin administered once daily to each group. On the 14th day, all rats were sacrificed, and their pancreas organs were dissected. Subsequently, observations were analyzed using ANOVA followed by DMRT. The results of the study showed that DKBS was able to improve the histopathological structure of the pancreas by increasing the diameter of the Langerhans islets.*

Keywords: Alloxan, Pancreatic diameter, Bischofia javanica stem bark.

Introduction

In the modern era, many lifestyle changes have occurred in society, especially in urban areas, leading to various health issues. These lifestyle changes are triggered by an increase in income, busy work schedules, causing the neglect of providing well-balanced nutritious meals. [1] stated that lifestyle changes and unhealthy eating patterns result in an imbalance between carbohydrates and other essential nutrients needed by the body. As a consequence, the sugar levels in the body become elevated, exceeding the pancreas's working capacity, leading to the occurrence of diabetes mellitus (DM).

According to data from the [2], an estimated 463 million people in the age group above 60 years live with diabetes, where 90% of them have type 2 diabetes. Within the period of 2013-

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2018, the number of diabetes patients increased by more than 20%, with approximately 70% remaining undiagnosed. Diabetes ranks third as the leading cause of death in Indonesia. Indonesia is the fourth country in the world with the highest number of diabetes patients, with around 12 million individuals, and it is estimated to increase to 21.3 million by 2030 [3]. If not addressed promptly, this situation will decrease the life expectancy of the Indonesian population.

Testing the anti-diabetic activity of a medicinal plant can be done in vitro, in silico, or in vivo. Inducing animal models for diabetes can be done in various ways, one of which is by using diabetogenic agents. A commonly used diabetogenic agent to assess the anti-diabetic potential of a medicinal plant is alloxan because of its ability to rapidly induce permanent hyperglycemia within two to five days. Alloxan is soluble in water and alcohol and is more cost-effective compared to streptozotocin [4,5]. Alloxan is a toxin capable of inducing diabetes with a dose of 150 mg/kg body weight in experimental animals due to its ability to damage pancreatic β cells.

The treatment of DM can be conducted in various ways, and one of them is through oral medication using metformin. However, this medication comes with side effects such as bloating, nausea, and diarrhea [6]. According to [7], traditional treatments are widely known among the community due to their few side effects, cost-effectiveness, and easy accessibility.

One plant with the potential to act as an anti-diabetic agent based on its chemical content is the sikkam plant (*Bischofia javanica*). This plant is found in the Tongkoh Nature Reserve in Karo Regency, North Sumatra, and is also widespread in Vietnam, India, China, the Philippines, and Indonesia [8]. According to [9], the sikkam plant is traditionally used by the Karo community as a remedy for stomach ulcers and infections. [10] also mentions that the sikkam plant is used for treating diabetes, cholesterol, and stomach pain, with the bark being the part of the plant used.

Based on literature reviews, there have been no reports found regarding the effects of Bischofia javanica leaf decoction on reducing blood glucose levels and improving pancreatic structure related to diabetes. Therefore, the researchers are interested in examining the effects of Bischofia javanica bark decoction on blood glucose levels and the histopathology of the pancreas in white rats induced with alloxan.

Materials and Methods

Extraction Method

The samples were obtained from the Silimakuta district in Simalungun Regency, North Sumatra Province. The bark was first selected while still fresh, cleaned with water, drained, and then dried at room temperature (25°C-30°C) until the bark became dry and brittle, flipping it occasionally. Next, it was ground using a blender and sieved with an 8-mesh sieve. To prepare a 10% concentration, 10 grams of dry powder was weighed and placed in an enamel pan, moistened with 100 ml of distilled water (aquades), and heated to 90°C for 30 minutes, stirring every 5 minutes. After cooling, it was filtered using filter paper. The same procedure was followed to make decoctions with concentrations of 5%, and 15% [11].

Experimental Procedure

The study followed a true experimental laboratory design. A total of 25 healthy white rats, aged 2.5 months with a weight range between 150-200 grams and no physical defects, were used as test subjects.

The research utilized a completely randomized design (CRD). The subjects were divided into five (5) groups: Group I (normal control), Group II received metformin, and Groups III, IV, and V were given decoctions with concentrations of 5%, 10%, and 15%, respectively. The

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administration period was 14 days. All groups except Group I were induced with alloxan at a dose of 150mg/kg body weight intraperitoneally to induce diabetes (fasting blood glucose ≥ 200 mg/dl), following the method described by [12].

The measurement of the diameter of the Langerhans islets was done by observing slides using an Olympus CX23 camera microscope with a magnification of 40x. Each slide was observed in four fields, and the diameter of the Langerhans islets was measured using raster image software. Body weight, blood glucose levels, and Langerhans islet diameters were tested using ANOVA. If there were differences between treatment groups, Duncan's test was conducted.

Results and Discussion

Body Weight

The data pertaining to the body weight of white rats (*Rattus norvegicus*) after the administration of Bischofia javanica bark decoction is presented in table 1.

Table 1. The effect of administration of B.ischofia javanica bark decoction on body weight of rats alloxan-induced diabetic

Treatment	Body weight (Mean ± SD) Day		
	1	7	14
P1(control)	192,2 ± 9,5 [a]	197,4 ± 10,7 [a]	200,4 ± 12,5 [a]
P2(Metformin)	170,6 ± 6,3 [b]	182,4 ± 7,5 [b]	190,8 ± 20,6 [ab]
P3 (5%)	171 ±10,0 [b]	169,6 ± 10,0 [b]	168,5 ± 3,6 [b]
P4(10%)	178,4 ± 9,9 [b]	175,4 ± 10,2 [b]	185,9 ± 23,6 [ab]
P5(15%)	178,2 ± 9,5 [b]	181,0 ± 8,12 [b]	189,8 ± 17,7 [ab]

*Different notations show significant differences ($p<0.05$).

On the first day, it can be observed that alloxan induction reduces the weight of the test animals compared to the control group. On the seventh day, weight gain occurred in the group treated with metformin (P2) and a 15% concentration of the decoction. However, there were no significant differences between the treatment groups. On the fourteenth day, there were no significant differences in body weight between the control group (P1), metformin administration (P2), and the administration of the decoction at concentrations of 10% and 15%. This indicates that the administration of decoctions with concentrations of 10% and 15% can restore the weight of the test animals.

Rats, as model animals, share physiological similarities in the pathogenesis of diabetes mellitus (DM) in humans based on their phenotypic characteristics [13]. DM is a metabolic disorder characterized by hyperglycemia due to disruptions in insulin secretion, insulin function, or both [14]. The weight of rats in each group is almost the same, except for the group given 5% BJB decoction (P3), which is lower than the other groups. This may be due to high glucose levels, leading to hunger and thirst, influencing body weight. However, the administration of 10% and 15% decoctions can increase the weight of the test animals. Bioactive compounds in this plant are believed to contribute to weight gain in diabetic rats. According to [15] and [16], this plant contains flavonoids, phenols, triterpenoids, and quercetin. Flavonoids provide hypoglycemic effects, regulate lipid metabolism related to gene expression, and can increase body weight [17]. Quercetin stimulates insulin release and increases Ca2+ absorption from Langerhans islet cells, affecting body weight and blood glucose levels. This occurs because quercetin inhibits the activity of α, a key enzyme in breaking down carbohydrates into glucose [18].

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Fasting Blood Glucose

The data for fasting blood glucose (FBD) levels after the administration of Bischofia javanica bark decoction is presented in table 2.

Table 2. The effect of administration of Bischofia javanica bark decoction on FBD of rats alloxan-induced Diabetic

Treatment	Fasting Blood Glucose (Mean ± SD) Day		
	1	7	14
P1(control)	85,2 ± 4,2 [a]	86,8 ± 6,0[a]	103±6,2[a]
P2(Metformin)	245,6 ± 54,3[b]	185 ± 56,1[b]	206±43,0 [b]
P3 (5%)	227,2 ± 54,3[b]	217 ± 56,0[b]	197±32,9[b]
P4(10%)	225,4 ± 57,1[b]	207 ±60,0[b]	185,9 ± 23,6 [ab]
P5(15%)	231 ± 89,4[b]	198 ± 48,0[b]	183± 69,0 [b]

*Different notations show significant differences ($p<0.05$).

Table 2 indicates a decrease in fasting blood glucose levels on the 7th and 14th days. On the 7th day, the administration of a 15% decoction had already reached values lower than 200 mg/dl, and on the 14th day, the administration of a 10% decoction also reached values lower than 200 mg/dl. This data suggests that the increase in the concentration of Bischofia javanica bark decoction is directly proportional to the decrease in fasting blood glucose levels.

Alloxan is commonly used to induce diabetes in test animals because it increases blood glucose levels or hyperglycemia. The mechanism of alloxan primarily involves the degradation of β cells, leading to a decrease in the quality and quantity of insulin production, resulting in hyperglycemia in the body. The induction mechanism of alloxan-induced diabetes begins with the absorption of alloxan by pancreatic β cells. Alloxan is reduced by the reducing agent glutathione (GSH) by binding to the SH group, resulting in the production of dialuric acid, which is then oxidized back to alloxan. The oxidation of alloxan leads to the formation of reactive oxygen species (ROS) and superoxide radicals that undergo dismutation, producing hydrogen peroxide [5]. This compound can increase Ca^{2+} in the cytosol by depolarizing pancreatic β cells, causing ion channels to open. The increase in Ca^{2+} and ROS causes damage to pancreatic β cells, resulting in decreased insulin production [19].

The decrease in fasting blood glucose levels is suspected to be due to the presence of chemical compounds such as flavonoids in this plant. According to [20], flavonoids have antidiabetic properties that can trigger a reduction in blood glucose levels. [21] stated that *Bischofia javanica* extract can lower blood glucose levels in alloxan-induced hyperglycemic rats. [22] also mentioned that flavonoids and alkaloids can reduce blood glucose levels in hyperglycemic rats. Furthermore, [23] stated that flavonoids are responsible for antidiabetic activity by inhibiting the formation of advanced glycation end products by reducing monosaccharide-induced protein glycation.

If compared to the normal control, the administration of Bischofia javanica decoction did not significantly decrease fasting blood glucose levels. This may be due to the given dosage being too low and might need to be increased.

Langerhans islets

The data on the diameter of Langerhans islets in white rats (Rattus norvegicus) is presented in table 3.

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Table 3. The effect of administration of Bischofia javanica bark decoction on diameter of Langerhans islets of rats alloxan-induced Diabetic

Treatment	Langerhans islets (µm) (Mean ± SD)
P1(control)	184.013 ± 9.02[a]
P2(Metformin)	115.029 ± 10,03[b]
P3 (5%)	98.488 ± 15,56[b]
P4(10%)	113.776 ± 12,56[b]
P5(15%)	114.253 ± 10,64[b]

*Different notations show significant differences ($p<0.05$).

Based on Table 3, it is observed that the variations in Bischofia javanica bark decoction were unable to increase the diameter of the Langerhans islets to normal sizes. However, when compared to metformin, there is no significant difference in the administration of decoction with concentrations of 10% and 15%. Therefore, these two concentrations exhibit similar effectiveness to metformin. The histological depiction of Langerhans islets is presented in Figure 1.

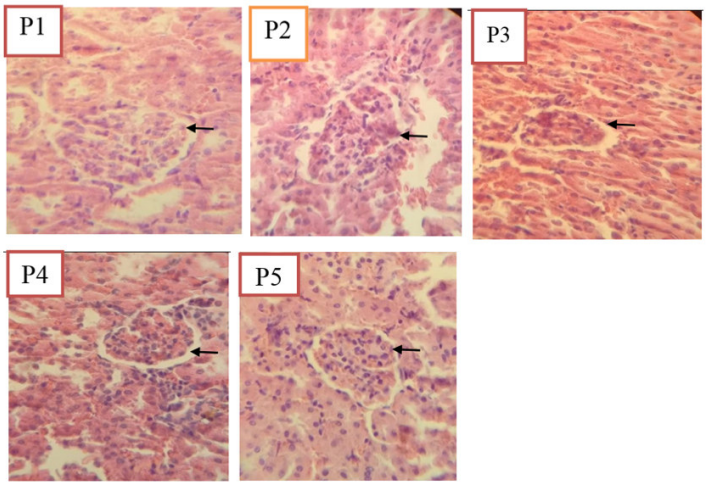

Figure 1. Pancreatic histology using H&E staining, magnification 40x. Arrowheads indicate the location of Langerhans islets: P1 (normal control); P2 (diabetic rats treated with metformin); P3 (diabetic rats treated with 5% decoction); P4 (diabetic rats treated with 10% decoction); P5 (diabetic rats treated with 15% decoction).

The reduction in the diameter of Langerhans islets after alloxan induction is caused by the diabetogenic binding to GLUT 2 on β cells, which can lead to cell destruction and necrosis. This results in a decrease in the number of cells, causing the Langerhans islets to undergo atrophy or shrink.

The administration of decoctions with concentrations of 10% and 15% appears to increase the diameter of Langerhans islets, although it does not reach normal values. This is believed to be due to the antioxidant activity possessed by this plant, which can reduce damage caused by alloxan. Additionally, pancreatic endocrine cells are stable cells with regenerative capabilities in the event of damage. These results indicate that the administration of decoctions from this plant can reduce the level of Langerhans islet damage by providing an opportunity for cell regeneration and increasing the size of the Langerhans islets. These findings are consistent with [24], who stated that the administration of binahong extract for 14 days showed a decrease in

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tissue damage with an increase in the process of pancreatic β cell regeneration. Furthermore, [25] found that the administration of sambiloto, which has similar extract content to Bischofia javanica, can reduce Langerhans islet damage and increase the number of β cells. [26] stated that flavonoids, as antioxidants, can repair Langerhans islet damage by inhibiting apoptosis-necrosis and increasing β cell regeneration. Meanwhile, quercetin can prevent damage to β cells due to oxidative stress, help increase insulin secretion, improve adiponectin circulation, inhibit glucosidase activity in the small intestine, and enhance GLUT 4 transporter in skeletal muscles [27].

Conclusion

Based on the results of this study, it can be concluded that the decoction of Bischofia javanica bark can improve blood glucose levels and pancreatic histopathology in white rats (Rattus norvegicus) induced with alloxan. Flavonoids, triterpenoids, and quercetin are suspected to be the contributing compounds. The administration of a 15% decoction concentration can lower blood glucose levels, increase body weight, and enhance the diameter of Langerhans islets.

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The effect of growth regulatoring substances iba (indole butyric acid) and naa (naphtalene acetat acid) on the growth of andaliman (*zanthoxylum acanthopodium* dc.) cuttings bud for plant cultivation the quality of export

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Abstract. *This research aims to determine the effect of IBA (Indole Butyric Acid) and NAA (Naphtaleine Acetic Acid) on the growth of Andaliman (Zanthoxylum acanthopodium DC.) shoot cuttings for cultivating export quality plants. The method used to achieve this goal was a direct experimental method with a 2 Factorial Completely Randomized Design (CRD) (IBA and NAA). IBA factors for 3 treatments (0, 500, 1000 mg/l) and NAA for 3 treatments (0, 250, 500 mg/l) with 9 treatment combinations and 5 replications with the research object being export quality andaliman parent trees. Parameters observed: number of live cuttings, shoot emergence time, shoot length, number of shoots and number of leaves. Data analysis used analysis of variance (Anova) 5% with the Duncan Multiple Range Test (DMRT) 5% with the SPSS version 26 program. Research results, 1) percentage of live cuttings of Andaliman 82.22% (37/45), 2) substances The growth regulator IBA has a significant effect on the time of shoot emergence, the number of shoots and the number of leaves of Andaliman (Zanthoxylum acanthopodium DC.), 3) the growth regulator NAA has a significant effect on the time of shoot emergence, the number of shoots and the number of leaves of Andaliman (Zanthoxylum acanthopodium DC.) and 4) the interaction of the growth regulators IBA and NAA has a significant effect on the time of shoot emergence, number of shoots and shoot length of Andaliman (Zanthoxylum acanthopodium DC.).*

Keywords: IBA, NAA, cuttings bud, andaliman, plant cultivation, quality export

Introduction

Andaliman has the Latin name Zanthoxylum acanthopodium and belongs to the Rutaceae family [16]. This plant is closely related to the Batak Ethnic. This is because andaliman fruit is used as a spice in traditional cooking of the Batak Ethnic, North Sumatra [19]. Such as arsik carp (carp cooked with added andaliman spices and without using coconut milk), natinombur (grilled fish with added andaliman spices) and sangsang (meat added with andaliman spices [14].

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Andaliman fruit has the characteristic that when eaten it feels bitter on the tongue [8]. Andaliman is not only used as a cooking spice but also to produce terpenoid substances with antioxidant, antimicrobial and immunostimulant activities [20][22]. Based on research [18], Andaliman has the potential to be used as medicine because Andaliman fruit extract is bactericidal against *Bacillus stearothermophilus bacteria, Pseudomonas aeruginosa, Vibrio cholera, and Salmonella typhimurium*.

Andaliman is characterized by red fruit, reddish green flower petals, branches appear near the base of the main stem, inflorescences start on the stem, young branches are red and dark red, have fine hairs and some are bald, the mother of the leaves is without thistles and has thorns [10]. It has a bushy appearance, height can reach 6 meters, woody stems, cylindrical round stems, stem diameter can reach 5-10 cm. The leaves are spread out, stemmed, the upper surface of the leaf is green while the lower surface is light green or pale green, and there are oil glands. The fruit is green when young and dark red when ripe. The seeds are hard and black, the flower petals are reddish green and yellowish green [6].

Based on research [5], andaliman is spread across North Sumatra Province, specifically in Dairi, Samosir, Simalungun, Toba Samosir, Karo and Humbang Hasundutan regencies. The main habitat of andaliman is in areas with an elevation of 1500-2000 m above sea level, and rainfall of 2000-2500 mm/year. Andaliman's habitat is quite narrow and occupies 6 types of land cover, namely dry land agricultural land, open land, settlements, secondary dry land forest, rice fields, and 2 bushes. Most of andaliman is found in acrisols and a small part in orthic podzols, cambisols and ferrasols.

Andaliman plants have low germination capacity and a long and variable germination age, namely around 24-100 days with a germination percentage of 17.5% [9]. According to [15], conventional andaliman cultivation with in situ conservation has been indirectly carried out by the Batak tribe. The need for andaliman plants as a typical spice for Batak cuisine has caused andaliman plants to be cultivated in their original location. Currently the andaliman population is very limited, ranging from 1000-2000 trees. The seeds obtained by farmers come from the forest, because andaliman seeds are difficult to germinate even though the growing conditions are optimal [13]. Apart from that, andaliman is also known as Batak pepper (Mangkuwidjojo et al, 1995). In each area, Andaliman has a different local name, in South Tapanuli it has the name Sinyar-nyar, in Karo it has the name intir-intir and Simalungun has the name tuba [21].

There are many reasons why the andaliman population is limited, one of which is the morphology of the andaliman seeds. The morphology of andaliman seeds is quite hard, so water is prevented from entering the seeds and results in their dormancy not working optimally. Not only that, the forest area in North Sumatra decreased by 994,452 Ha from 2001 to 2014 as a result of illegal logging, forest fires, land conversion to monoculture plantations, land conversion to residential areas. It would be a shame if no effort was made to conserve it. For this reason, researchers need to carry out in situ conservation efforts, namely in their natural habitat, through cuttings of andaliman stems and shoots.

Vegetative propagation through cuttings is a very important initial factor during plant growth. In general, shoots will form and grow after the roots are well formed. Generally, vegetative propagation will grow if the roots develop well [7].

Reproduction of plant vegetative organs is done to form new plants that are perfect in the roots, stems and leaves, usually the new plants have the same characteristics as their parents. The characteristics that you want to maintain are high yield, good quality and resistance to disease. In

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connection with this, many efforts have been made to stimulate, encourage and accelerate root formation and increase the number of roots and root quality by administering growth regulators such as *Indole Acetic Acid* (IAA), *Indole Butyric Acid* (lBA), *u-Naphthalene Acetic Acid* (NAA), *Indole Aceto Nitrile* (IAN), *Phenoxy Acetic Acid* (PAA), and so on [4][1].

Vegetative propagation, especially by cuttings takes a long time of two to four months depending on the plant species to allow the plant to quickly grow well. However, by administering growth regulators, it can be shortened and the plant's life is likely to be longer [2]. Meanwhile, according to [12] one effort to increase the success of shoot cuttings is by using appropriate substance growth regulators.

The IBA hormone (Indole Butyric Acid) is a type of hormone used to stimulate root formation [12]. The IBA hormone has benefits that can stimulate root formation, accelerate plant growth, increase seedling rooting after transplanting and can induce plant root elongation. Apart from IBA, the hormone NAA (Napthalene Acetic Acid) plays a role in stimulating lateral root growth, inducing cell expansion and root initiation [3][12]. Therefore, the NAA hormone is very suitable to be used to induce plant roots.

Materials and Methods

Location and Time of Research

The research was conducted in Eden Garden 100 Lumban Julu District Toba Regency. The research period is from April to November 2023.

Population and Sample

The population is all Andaliman plants found in Eden Gardens 100. Then samples are taken based on export criteria: healthy plants, fruit colour light green to blackish brown, a maximum of 1-2 cm stems, free from other by-products (such as soil, stalks, stems and leaves), not mouldy and free from insects, required documents (phytosanitary certificate and certificate of origin).

Tools and Materials

The tools used in this study were polybags, crop scissors, plant knife, analytical balance, beaker glass, erlenmeyer, measuring cup, dropper, bucket, rag, label paper, tape, calliper, 30 cm ruler and other stationery. The materials used in this study were cocopeat media using a flute, andaliman shoots from Eden Garden 100, Lumban Julu District, Toba Regency, North Sumatra.

Research Design

This research used a completely randomized design (CRD) factorial, namely the IBA factor of 3 treatments: 0, 500, 1000 mg/l and the NAA factor of 3 treatments: 0, 250, 500 mg/l, so there were 9 (3 x 3) combinations. The each treatment with 5 replications. Data were analyzed using Anova (Analysis of Variance) 5% to determine the effect of treatment. Further tests used 5% DMRT to determine differences between treatments using the SPSS program version 26.

Parameter

The parameters observed were: 1) number of live cuttings, 2) time of shoot appear, 3) number of shoots, 4) length of shoots, 5) number of leaves.

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Data Analysis

Data analysis used Analysis of Variance (Anova) 5% to determine the effect of treatment. Further tests used 5% DMRT to determine the differences between treatments.

Results and Discussion

The Number of Live Cuttings

The number of live cuttings treated with various concentrations of IBA and NAA growth regulators can be seen in Table 1.

Table 1. Effect of growth regulators IBA and NAA on the number of live cuttings of Andaliman (*Zanthoxylum acanthopodium* DC.)

Num.	Treatment	Replication					Amount	Average
		1	2	3	4	5		
1	IBA_0NAA_0	0	1	1	0	0	2	0,4
2	IBA_0NAA_{250}	1	1	1	1	1	5	1,0
3	IBA_0NAA_{500}	1	0	1	0	1	3	0,6
4	$IBA_{500}\,NAA_0$	1	1	1	1	1	5	1,0
5	$IBA_{500}NAA_{250}$	1	1	0	1	1	4	0,8
6	$IBA_{500}NAA_{500}$	1	1	1	1	1	5	1,0
7	$IBA_{1000}NAA_0$	0	1	1	1	0	3	0,6
8	$IBA_{1000}NAA_{250}$	1	1	1	1	1	5	1,0
9	$IBA_{1000}\,NAA_{500}$	1	1	1	1	1	5	1,0

Table 1 shows the total number of live cuttings of Andaliman (*Zanthoxylum acanthopodium* DC.) is 37 cuttings and the number of dead cuttings is 8 cuttings, the percentage of live cuttings is 82.22% (37/45). The average number of Andaliman live cuttings varied for several treatments, the highest number of live cuttings was obtained in treatment numbers 2, 4, 6, 8 and 9, namely 1.0 cuttings. The lowest average number of live cuttings in treatment number 1 was 0.4 cuttings. Next, to determine the effect of the growth regulators IBA and IAA on the number of live cuttings, the data in Table 1 was processed using analysis of variance (Anava) at a significance level of 5%. Because there is zero data, the data is transformed to $\sqrt{x + 0.5}$ as shown in Table 2. Table 2 shows that the highest average value for the number of live cuttings resulting from transformation is 1.2250 cuttings and the lowest is 0.8106 cuttings, the distance between the highest and lowest values is 0.4144 (1.2250 - 0.8106) cuttings. This range of values will be analyzed to determine the effect of IBA and NAA growth regulator treatment on the number of live cuttings of Andaliman (*Zanthoxylum acanthopodium* DC.) using SPSS version 26, as shown in Table 3.

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Table 2. Data transformation to $\sqrt{x + 0.5}$ effect of IBA and NAA growth regulators on the number of live cuttings

Num.	Treatment	Replication					Amount	Average
		1	2	3	4	5		
1	IBA_0NAA_0	0,707	1,225	1.225	0,707	0,707	4,053	0,8106
2	IBA_0NAA_{250}	1,225	1,225	1,225	1,225	1,225	6,125	1,2250
3	IBA_0NAA_{500}	1,225	0,707	1,225	0,707	1,225	5,089	1,0178
4	$IBA_{500}\,NAA_0$	1,225	1,225	1,225	1,225	1,225	6,125	1,2250
5	$IBA_{500}NAA_{250}$	1,225	1,225	0,707	1,225	1,225	5,607	1,1214
6	$IBA_{500}NAA_{500}$	1,225	1,225	1,225	1,225	1,225	6,125	1,2250
7	$IBA_{1000}NAA_0$	0,707	1,225	1,225	1,225	0,707	5,089	1,0178
8	$IBA_{1000}NAA_{250}$	1,225	1,225	1,225	1,225	1,225	6,125	1,2250
9	$IBA_{1000}\,NAA_{500}$	1,225	1,225	1,225	1,225	1,225	6,125	1,2250

Table 3. Analysis of variance (Anava) of the effect of IBA and NAA growth regulators on the number of live cuttings of Andaliman (*Zanthoxylum acanthopodium* DC.)

Variation	df	JK	KT	F-count	Sig.
Treatment:	8	0,584			
IBA	2	0,155	0,078	2,364	$0,109^{ns}$
NAA	2	0,155	0,078	2,364	$0,109^{ns}$
IBAxNAA	4	0,274	0,069	2,091	$0,102^{ns}$
Error	36	1,181	0,330	-	-
Total	44	1,765	-	-	-

Note: Sig. value > 0.05 is no significant (ns) and no needed further test.

The results of the analysis of variance regarding the effect of IBA and NAA growth regulators on the number of live cuttings of Andaliman (*Zanthoxylum acanthopodium* DC.) were that the effect was not significant because the significance value (sig.) was greater than 0.05. Because the treatment showed no significant effect, further tests (post-hoc) did no need to be carried out to see treatment differences.

Shoot Appear Time

Shoot appear time with various treatments of IBA and NAA growth regulator concentrations can be seen in Table 4. Table 4 shows the time for shoot appear due to the influence of the growth regulators IBA and NAA. The average time for shoot appear varies for each treatment. The fastest average time for shoot appear after planting was in treatment number 6 (IBA500NAA500), namely 17 days, while the longest time for shoot appear after planting was in treatment number 1 (IBA0NAA0), namely 35 days. The difference between the average time for emergence of the slowest shoots and the fastest is 18 (35 – 17) days, this time difference will be analyzed using analysis of variance to determine the effect of IBA and NAA growth regulators on the emergence time of shoot cuttings of Andaliman (*Zanthoxylum acanthopodium* DC.), as seen

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in Table 5.5. From the table, it can be seen that there is an influence of the single factor growth regulator IBA, the NAA factor and the interaction factor IBA and NAA, because the significance value (sig.) is smaller than 0.05. This means that there is a real influence of the growth regulators IBA and NAA on the appear time of Andaliman shoot cuttings (*Zanthoxylum acanthopodium* DC.).

Table 4. The effect of growth regulators IBA and NAA on shoot appear time (days) of Andaliman (*Zanthoxylum acanthopodium* DC.)

Num.	Treatment	Replication					Amount	Average
		1	2	3	4	5		
1	IBA_0NAA_0	-	35	37	-	-	72	36
2	IBA_0NAA_{250}	32	29	34	30	30	155	31
3	IBA_0NAA_{500}	28	-	33	-	29	90	30
4	$IBA_{500}\ NAA_0$	30	26	32	25	27	140	28
5	$IBA_{500}NAA_{250}$	18	24	-	22	20	84	21
6	$IBA_{500}NAA_{500}$	16	19	18	15	17	85	17
7	$IBA_{1000}NAA_0$	-	30	32	34	-	96	32
8	$IBA_{1000}NAA_{250}$	24	26	22	25	28	125	25
9	$IBA_{1000}\ NAA_{500}$	26	28	30	27	24	135	27

Table 5. Analysis of variance (Anova) of the effect of IBA and NAA on the shoot appear time of Andaliman (*Zanthoxylum acanthopodium* DC.)

Variation	df	SS	MS	F-count	Sig.
Treatment:	8	974,592			
IBA	2	602,999	301,500	58,625	0,000*
NAA	2	308,814	154,407	30,024	0,000*
IBAxNAA	4	62,779	15,695	3,052	0,033*
Error	28	144,000	5,143	-	-
Total	36	1.118,592	-	-	-

Note: Sig. value < 0.05 significantly different (*), further test interaction for IBA x NAA, SS = Sum of Square, MS = Mean of Square, df = degree of freedom

The results of test DMRT 5% further showed that there were differences between treatments as follows, treatment number 6 was significantly different from treatments numbers 5, 8, 9, 4, 3, 2, 7 and 1. Treatment number 5 was different from treatments numbers 8, 9, 4 , 3, 2, 7 and 1. Treatment number 8 is the same as treatment numbers 9 and 4, but significantly different from treatment numbers 3, 2, 7 and 1. Treatment number 9 is the same as treatment numbers 4 and 3, but significantly different from treatment numbers 2, 7 and 1. Treatment number 4 is the same as treatment numbers 3 and 2, but significantly different from treatment numbers 7 and 1. Treatment number 3 is the same as treatment numbers 2 and 7, but significantly different from treatment number 1. Treatment number 7 different from treatment number 1.

In order of notation in Table 5.6, there are four groups, namely notation groups c, d, e and f. The notation group c with treatment numbers 8, 9 and 4, the notation group d with treatments 9, 4 and

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3, the notation group f with treatment numbers 4, 3 and 2; notation group f with treatment numbers 3, 2 and 7.

Table 6. Test DMRT 5% on the effect of IBA and NAA on the shoot appear time of andaliman (*Zanthoxylum acanthopodium* DC.)

No.	Perlakuan	Subset α 5%							Notasi
		1	2	3	4	5	6	7	
6	$IBA_{500}NAA_{500}$	17							a
5	$IBA_{500}NAA_{250}$		21						b
8	$IBA_{1000}NAA_{250}$			25					c
9	$IBA_{1000}NAA_{500}$			27	27				cd
4	$IBA_{500}NAA_{0}$			28	28	28			cde
3	$IBA_{0}NAA_{500}$				30	30	30		def
2	$IBA_{0}NAA_{250}$					31	31		ef
7	$IBA_{1000}NAA_{0}$						32		f
1	$IBA_{0}NAA_{0}$							36	g

Number Shoots

The next parameter observed and measured was the number of shoots, as shown in Table 7.

Table 7. Effect of growth regulators IBA and NAA on the number of shoots of Andaliman (*Zanthoxylum acanthopodium* DC.)

Num.	Treatment	Replication					Amount	Average
		1	2	3	4	5		
1	$IBA_{0}NAA_{0}$	-	1	1	-	-	2	1,00
2	$IBA_{0}NAA_{250}$	1	1	1	1	1	5	1,00
3	$IBA_{0}NAA_{500}$	2	-	2	-	2	6	2,00
4	$IBA_{500}\,NAA_{0}$	2	1	1	2	1	7	1,40
5	$IBA_{500}NAA_{250}$	2	2	-	2	2	8	2,00
6	$IBA_{500}NAA_{500}$	2	2	2	2	2	10	2,00
7	$IBA_{1000}NAA_{0}$	-	1	2	2	-	5	1,67
8	$IBA_{1000}NAA_{250}$	1	2	2	2	2	9	1,80
9	$IBA_{1000}\,NAA_{500}$	2	1	2	1	2	8	1,60

Table 7 shows the number of shoots for each treatment and replication. The highest average number of shoots was obtained in treatment numbers 3, 5 and 6, namely 2 shoots per live cutting, while the lowest average number of shoots was obtained in treatment numbers 1 and 2, namely 1 shoot per live cutting. The distance between the highest number of shoots and the lowest number of shoots is 1. Next is to find out the effect of the regulatory substance IBA and NAA, then the data above was analyzed using 5% variance analysis as shown in Table 8.

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Table 8. Analysis of variance (Anova) of the effect of IBA and NAA on the number of shoots of Andaliman (*Zanthoxylum acanthopodium* DC.)

Variation	df	SS	MS	F-count	Sig.
Treatment:	8	4,663			
IBA	2	1,202	0,601	4,353	0,023*
NAA	2	1,356	0,678	4,908	0,015*
IBAxNAA	4	2,105	0,526	3,810	0,014*
Error	28	3,867	0,138	-	-
Total	36	8,530	-	-	-

Note: Sig. value < 0.05 is significantly different (*)

The results of the analysis of variance in Table 8 show that there is a real influence of the single factors IBA and NAA as well as interaction factors because the significance value (sig.) is smaller than 0.05. Next, to determine the differences between treatments, a further 5% DMRT test was carried out, as shown in Table 9.

Table 9. Test DMRT 5% of the effect of IBA and NAA on the number of andaliman shoots (*Zanthoxylum acanthopodium* DC.)

Num.	Treatment	Subset α 5%		Notation
		1	2	
1	IBA0NAA0	1,00		a
2	IBA0NAA250	1,00		a
4	IBA500NAA0	1,40	1,40	ab
9	IBA1000NAA500	1,60	1,60	ab
7	IBA1000NAA0		1,67	b
8	IBA1000NAA250		1,80	b
3	IBA0NAA500		2,00	b
5	IBA500NAA250		2,00	b
6	IBA500NAA500		2,00	b

Table 9 shows the differences between treatment combinations, treatment number 1 is the same as treatment numbers 2, 4 and 9, but different from treatments number 7, 8, 3, 5 and 6. Treatment number 2 is the same as treatment numbers 4 and 9, but different with treatment numbers 7, 8, 3, 5 and 6. Treatment number 4 is the same as treatment numbers 9, 7, 8, 3, 5 and 6. Treatment number 9 is the same as treatment numbers 7, 8, 3, 5 and 6. Treatment number 7 is the same as treatment numbers 8, 3, 5 and 6. Treatment number 8 is the same as treatment numbers 3, 5 and 6. Treatment number 3 is the same as treatment numbers 5 and 6. Treatment 5 is the same as treatment 6. Lower case notation indicates letters small a and b, meaning there are two treatment groups that are the same, namely group a consists of treatment numbers 1, 2, 4 and 9 and group b consists of treatment numbers 4, 9, 7, 8, 3, 5 and 6. There are two treatments the ones that intersect are treatment numbers 4 and 9.

Shoot Length

The next parameter to be observed and measured is shoot length, as shown in Table 10. Table 10 shows the average length of various shoots. The highest shoot length was obtained in treatment number one, namely 3.5 cm and the lowest in treatment number three, namely 2.2 cm. Next, to determine the effect of the growth regulators IBA and NAA on shoot length, data analysis was carried out using analysis of variance at a significance level of 5%, as shown in Table 11.

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The results of the analysis of variance show that there is no real influence of each single factor of IBA and NAA because the significance value (sig.) is greater than 0.05. Furthermore, a real effect can be seen in the interaction between IBA and NAA because the significance value (sig.) is smaller than 0.05. Differences between treatments due to the interaction of the growth regulator IBA and NAA can be seen in Table 12.

Table 10. Effect of growth regulators IBA and NAA on shoot length of Andaliman (*Zanthoxylum acanthopodium* DC.)

Num.	Treatment	Replication					Amount	Average
		1	2	3	4	5		
1	IBA_0NAA_0	-	3,7	3,3	-	-	7,0	3,50
2	IBA_0NAA_{250}	3,1	2,8	3,3	3,5	3,4	16,1	3,22
3	IBA_0NAA_{500}	2,3	-	2,1	-	2,2	6,6	2,20
4	$IBA_{500}\ NAA_0$	2,0	3,3	3,5	2,1	3,2	14,1	2,82
5	$IBA_{500}NAA_{250}$	3,0	2,5	-	2,7	2,6	10,8	2,70
6	$IBA_{500}NAA_{500}$	2,0	2,6	2,8	2,9	2,3	12,6	2,52
7	$IBA_{1000}NAA_0$	-	3,6	2,6	2,8	-	9,0	3,00
8	$IBA_{1000}NAA_{250}$	3,2	2,2	2,4	2,8	2,2	12,8	2,56
9	$IBA_{1000}\ NAA_{500}$	3,4	3,5	2,7	3,7	2,5	15,8	3,16

Table 11. Analysis of variance (Anova) of the effect of IBA and NAA on shoot length of Andaliman (*Zanthoxylum acanthopodium* DC.)

Varation	df	SS	MS	F-count	Sig.
Treatment:	8	4,869			
IBA	2	0,562	0,281	1,419	$0,259^{tn}$
NAA	2	1,174	0,587	2,962	$0,068^{tn}$
IBAxNAA	4	3.133	0,783	3,953	0,011*
Error	28	5,548	0,198	-	-
Total	36	10,417	-	-	-

Note: Sig. value < 0.05 significantly different for the IBAxNAA interaction (next test DMRT 5%)

Further test DMRT 5% on the effect of IBA and NAA on the number of shoots from Andaliman shoot cuttings (*Zanthoxylum acanthopodium* DC.) showed that there were significant differences between treatments. Treatment number 3 is the same as treatment numbers 6, 8, 5 and 4, but significantly different from treatment numbers 7, 9, 2 and 1. Treatment number 6 is the same as treatment numbers 8, 5, 4, 7, 9 and 2, but different with treatment 1. Treatment number 8 is the same as treatment numbers 5, 4, 7, 9 and 2, but different from treatment 1. Treatment number 5 is the same as treatment numbers 4, 7, 9 and 2, but different from treatment 1. Treatment number 4 is the same as treatment numbers 7, 9, 2 and 1. Treatment number 7 is the same as treatment numbers 9, 2 and 1. Treatment number 9 is the same as treatment numbers 2 and 1. Treatment number 2 is the same as treatment number 1

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Table 12. Test DMRT 5% of the effect of IBA and NAA on the number of shoots of Andaliman (*Zanthoxylum acanthopodium* DC.)

No.	Perlakuan	Subset α 5%			Notasi
		1	2	3	
3	IBA0NAA500	2,20			a
6	IBA500NAA500	2,52	2,52		ab
8	IBA1000NAA250	2,56	2,56		ab
5	IBA500NAA250	2,70	2,70		ab
4	IBA500NAA0	2,86	2,86	2,86	abc
7	IBA1000NAA0		3,00	3,00	bc
9	IBA1000NAA500		3,16	3,16	bc
2	IBA0NAA250		3,22	3,22	bc
1	IBA0NAA0			3,50	c

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In terms of treatment notation, there are three treatment groups that are the same, namely a, b and c. Group a with treatment numbers 3, 6, 8, 5 and 4; group b with treatment numbers 6, 8, 5, 4, 7, 9 and 2; and group c with treatment numbers 4, 7, 9, 2 and 1. There are treatments that intersect AB, namely treatment numbers 6, 8, 5 and 4; abc intersection treatment, namely treatment number 4; bc intersection treatments, namely treatments 7, 9 and 2.

Number of Leaves

The last parameter observed and measured was the number of leaves, as seen in Table 13.

Table 13. Effect of growth regulators IBA and NAA on the number of Andaliman leaves (*Zanthoxylum acanthopodium* DC.)

Num.	Treatment	Replication					Acount	Average
		1	2	3	4	5		
1	IBA_0NAA_0	-	3	2	-	-	5,0	2,50
2	IBA_0NAA_{250}	4	3	3	3	4	17,0	3,40
3	IBA_0NAA_{500}	3	-	4	-	3	10,0	3,33
4	$IBA_{500}\,NAA_0$	3	3	2	4	3	15,0	3,00
5	$IBA_{500}NAA_{250}$	3	4	-	5	5	17,0	4,25
6	$IBA_{500}NAA_{500}$	6	5	4	5	6	26,0	5,20
7	$IBA_{1000}NAA_0$	-	3	5	5	-	13,0	4,33
8	$IBA_{1000}NAA_{250}$	3	6	4	5	4	22,0	4,40
9	$IBA_{1000}\,NAA_{500}$	4	3	6	4	5	22,0	4,40

Table 13 shows the effect of the growth regulators IBA and NAA on the number of leaves Andaliman (*Zanthoxylum acanthopodium* DC.). The highest average number of leaves was in treatment number 6, namely 5.20, and the lowest was in treatment number 1, namely 2.5. The distance between the highest number of leaves and the lowest number was 2.70 (5.20 – 2.50) pieces. The number of leaves for each treatment was analyzed using 5% analysis of variance (Anova) with SPSS version 26 as shown in Table 14.

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Table 14. Analysis of variance (Anova) of the effect of IBA and NAA on the number leaves of Andaliman (*Zanthoxylum acanthopodium* DC.)

Variance	df	SS	MS	F-count	Sig.
Treatment:	8	19,193			
IBA	2	7,288	3,644	4,145	0,027*
NAA	2	6,580	3,290	3,742	0,036*
IBAxNAA	4	5,325	1,331	1,514	0,225tn
Error	28	24,617	0,879	-	-
Total	36	43,810	-	-	-

Note: * (significantly) significance value < 0.05), tn (no significant) significance value > 0.05.

Table 14 shows the results of analysis of variance (Anova) of the effect of the growth regulators IBA and NAA on the number of leaves Andaliman (*Zanthoxylum acanthopodium* DC.). The single factors IBA and NAA have a real influence, while the interaction factors have no real influence. To see the differences in single factor treatment, a further test DMRT 5% was carried out using the SPSS version 26 program, the results can be seen in Table 15.

Table 15. Effect of growth regulators IBA and NAA on the number leaves of Andaliman (*Zanthoxylum acanthopodium* DC.)

IBA	NAA			Average
	0	250	500	
0	2,50	3,40	3,33	3,08 a
500	3,00	4,25	5,20	4,15 b
1000	4,33	4,40	4,40	4,38 b
Average	3,27a	4,02 ab	4,31 b	-

Table 15 shows the influence of the single factor growth regulator IBA and NAA. The treatment with the IBA_0 concentration was significantly different from the IBA_{500} and IBA_{1000} concentration treatments, the IBA_{500} concentration treatment was the same as the IBA_{1000} concentration treatment. The treatment with the NAA_0 concentration was the same as the NAA_{250} concentration treatment, but was significantly different from the NAA_{500} concentration treatment, the NAA_{250} concentration treatment was the same as the IBA_{500} concentration treatment.

Table 16. Recapitulation of the results of the variance analysis for each parameter and factor

Num.	Parameter	Significant Factor		
		IBA	NAA	IBAxNAA
1	Number of live	ns	ns	ns
2	Shoot appear of time	*	*	*
3	Number of shoots	*	*	*
4	Length of shoots	ns	ns	*
5	Number of Leaves	*	*	ns

Note: ns = no significant, * = significant

Table 16 shows that the administration of IBA, NAA and the IBA x NAA interaction had no effect on the parameters of the number of live cuttings [3]. Then the opposite happened to the parameters of shoot appear time and number of shoots, there was a real influence on the provision of IBA, NAA and the interaction of IBA x NAA. For the shoot length parameter, the interaction factor IBA x NAA has an influence, while for leaf number only the single factors IBA and NAA

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have a significant effect. In accordance with the opinion of [1][3][4] IBA and stimulates root growth, then the roots have an influence on the upper plant organs.

From Tables 7 and 10, it can be seen that there is a strong negative relationship between the number of shoots and shoot length, as seen in Figure 1 and Figure 2.

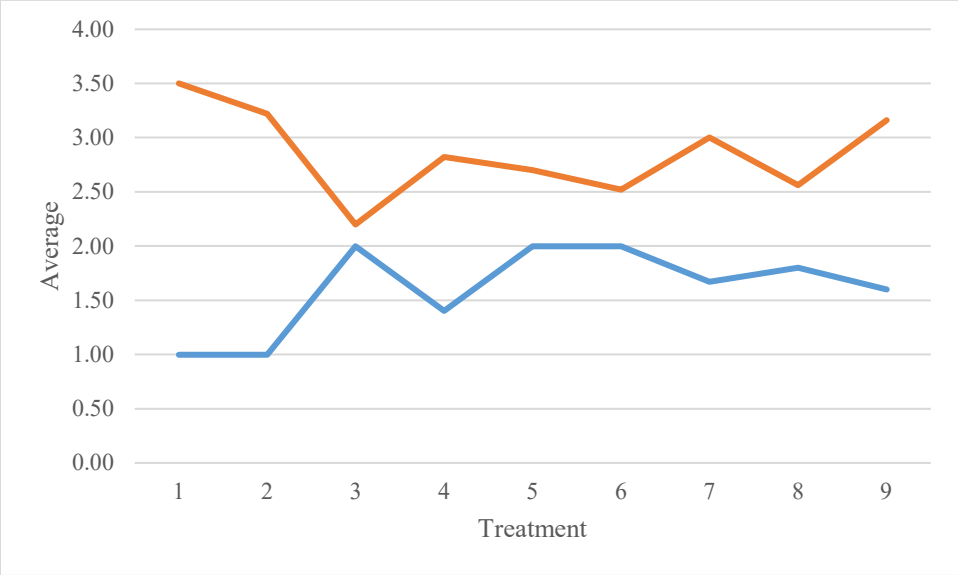

Figure 1. Effect of growth regulators IBA and NAA on the number and length of shoots from Andaliman shoot cuttings (*Zanthoxylum acanthopodium* DC.)
(= Number Shoots, = Length Shoots)

Figure 1 shows the relationship between the number of shoots and shoot length, in treatment number 1 the number of shoots was the lowest and the shoot length was the highest, this also happened in treatments numbers 2, 4, 7 and 9. The relationship value (r = correlation) can be seen in Figure 2.

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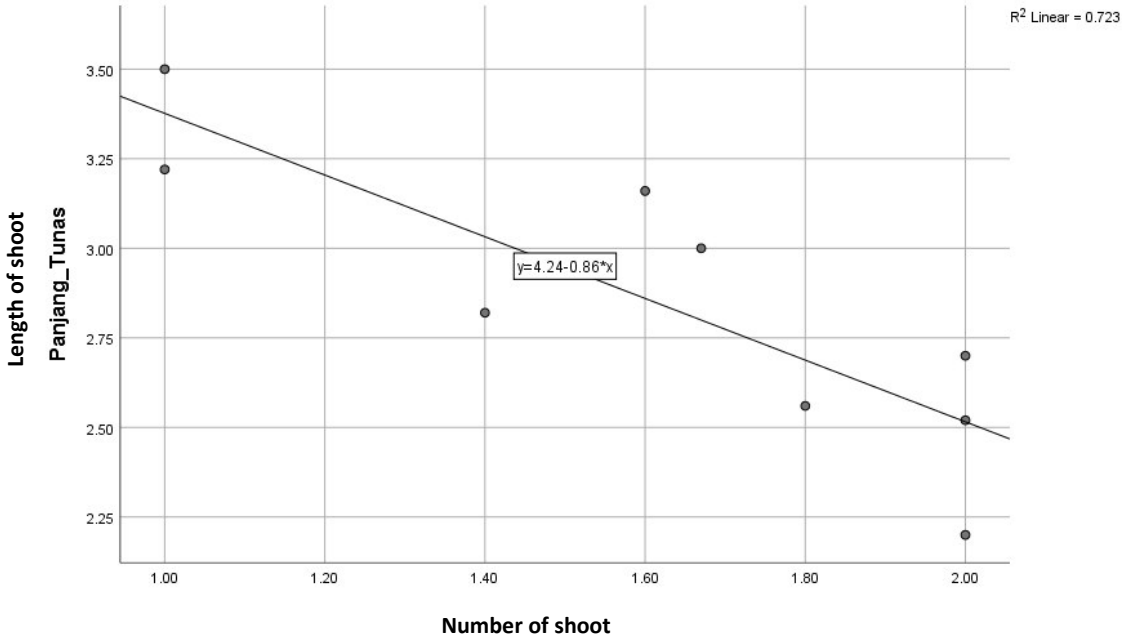

Figure 2. The relationship between the average number and length of shoots with r = -0.85 (r^2 linear = 0.723)

Conclusion

The percentage of live cuttings of Andaliman (*Zanthoxylum acanthopodium* DC.) with IBA and NAA growth regulators was 82.22%. There is a real influence of the growth regulator IBA on the time appears of shoot, number of shoots and number of leaves of Andaliman (*Zanthoxylum acanthopodium* DC.). There is a real influence of the growth regulator NAA on the time of shoot emergence, number of shoots and number of leaves of Andaliman (*Zanthoxylum acanthopodium* DC.). There was a real influence of the growth regulators IBA and NAA on the time of shoot emergence, number of shoots and shoot length of Andaliman (*Zanthoxylum acanthopodium* DC.).

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Species characterization of three *tor* species (family cyprinidae) based on morphometric analysis

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Abstract. *This study aims to classify three Tor fish species collected from Tangkahan Waters, North Sumatra, Indonesia. Sampling was conducted three times in the period from January to March 2023. The research used an exploratory survey method. The fish samples collected were then measured for morphometrics and then analyzed using univariate (ANOVA) and multivariate (Discriminant Function Analysis/DFA). Univariate analysis showed that there were almost all morphometric characters (23 characters) in the three Tor species were significantly different (P<0.05), only three characters were not significantly different (P>0.05). The results of the multivariate analysis succeeded in classifying fish based on their respective species. This analysis produces two functions, where functions I and II have eigenvalues reaching 2.50 and 1.39 with the % of variance values of each function reaching 64.1% and 35.9%. The results of univariate and multivariate analysis have succeeded in classifying three fish species based on their morphometric characteristics. These results indicate that each species has specific characteristics that differentiate between fish species. These results also succeeded in revealing morphological differences in species even though the fish had high similarities.*

Keywords: Univariate, Multivariate, Eigenvalues, Species, Tor

Introduction

North Sumatra is one of the areas in Indonesia that has the potential for a relatively large water area. There are 99 main rivers and 783 tributaries flowing in North Sumatra Province [1]. The river is an inland water which is characterized by a continuous flow of water flowing from upstream to downstream to the estuary. The river is also a habitat for living organisms to find food and reproduce [2]. One of the important organisms that inhabit river waters is the *Tor* group. This fish has important economic value for the people who live around the fish's habitat [3].

Genus *Tor* is a native Indonesian freshwater fish whose existence is threatened with extinction. This is due to uncontrolled fishing and habitat destruction [4]. Based on the publication of the IUCN Red List in 2018, there are 16 species of fish from the *Tor* group that are threatened [5], including *Tor douronensis*, *T. tambra*, and *T. tambroides* and *T. soro* in Indonesia [6]. In addition, the slow growth factor is an obstacle for this fish to increase its population, where the development cycle from larva to mature takes about four years [7].

The results of observations made on the rivers in Tangkahan found three *Tor* species, namely *T. douronensis*, *T. tambra*, and *T. tambroides*. *Tor* fish is very popular with local people for consumption because it has thick meat, delicious taste, and a high omega-3 content so it has high economic value [8]. This factor causes the *Tor* fish to become a hunting target for consumption and commercial purposes. Therefore, it is urgent to carry out conservation efforts. One of them is by validly identifying this fish species based on morphological characters. This is because fishermen consider all *Tor* fish caught to be the same species so the results of this study can be used as a reference for the community and policymakers to conserve fish species. This morphometric study is a relatively easy method to determine species that have high similarity so it is hoped that it can answer the problems in determining *Tor* fish species in the community and researchers.

Materials and Methods

Time and site

This research was conducted in January-March 2023. Sampling was carried out at the Tangkahan River (3°45'50.46" N; 98°14'52.66" E), Langkat Regency, North Sumatra Province, Indonesia,

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which is the habitat of the *Tor* fish. Morphometric measurements were carried out at the Biology Laboratory, FMIPA, Universitas Negeri Medan, Indonesia.

Data collection

Data collection in this study was an exploratory survey [4]. Sampling was carried out in the field with three repetitions. The identification of the *Tor* fish refers to [6] by having a lower median lobe that is short in size, the upper bone has a convex shape and widened lateral parts, the tip of the head is blunt, usually a reddish body color [9]. In addition, the identification that we can see in *Tor*'s characteristics is the number of barbells, and the color of the eyes at the edges [10]. Furthermore, the identification of *Tor* fish that is most often carried out is the presence or absence of lobes and differences in lobe sizes [11].

Morphometric measurement

The morphometric study of this study refers to the research of [12]. The morphological characteristics of fish determine their morphometric characteristics. In this study, 25 morphometric characters were determined and presented in Fig. 1. This morphometric measurement uses a digital caliper error of 0.01 mm.

Data analysis

The entire data that has been obtained is transformed to obtain homogeneous morphometric measurement data so that it meets the assumptions of analysis, using the formula [13]:

$$Transformation = \frac{M\ x\ 100}{TL}$$

Note: M = all measured characters except TL, TL = total length

After transforming the data, the morphometric measurement data were analyzed in a univariate (ANOVA) and multivariate (Discriminant Function Analysis/DFA) manner referring to [14] using SPSS ver. 24.

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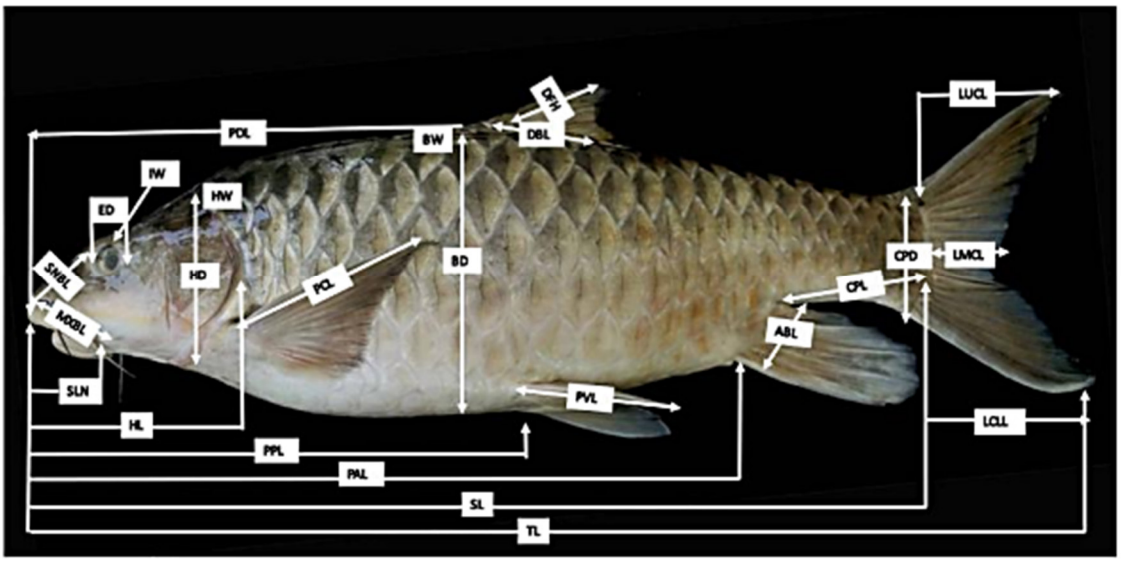

Figure 1. The Fish Morphometric Measurement Scheme refers to Akmal et al. (2018), where Description: ABL: anal fin base length; BD: body depth; BW: Body width; CPD: caudal peduncle depth; CPL: caudal peduncle length; DBL: dorsal fin base length; DFH: dorsal fin height; ED: eye diameter; HD: head depth; HL: head length; HW: head width; IW: distance between eyes; LCLL: lower caudal fin length; LMCL: mid caudal fin length; LUCL: upper caudal fin length; MXBL: maxillary barbel length; PAL: pre anal fin length; PCL: pectoral fin lenth; PDL: pre dorsal fin length; PPL: pre pelvic fin length; PVL: pelvic fin lenth; SL: standard length; SNBL: snout length; and TL: total length.

Results and discussion

ANOVA analysis showed that almost all of the morphometric characters in the three *Tor* species were significantly different ($P<0.05$), and only three characters were not significantly different ($P>0.05$). The morphometric characters that were not significantly different included CPL, PAL, and SL, while the morphometric characters that were significantly different included APL, BD, BW, CPD, DBL, DFH, ED, HD, HL, HW, IW, LCLL, LMCL, LUCL, MXBL, PCL, PDL, PPL, PVL, SNBL, and SNL (Table 1). The results of this analysis show that morphologically each species has a specific distinguishing character.

The results of the multivariate analysis (discriminant function analysis/DFA) succeeded in classifying fish based on their respective species. This analysis produces two functions, where functions I and II have eigenvalues reaching 2.50 and 1.39 with the % of variance values of each function reaching 64.1% and 35.9%. The characters that contribute to function I include SNBL, ED, PPL, HD, ABL, HL, SL, HW, BD, and PAL, while those in function II include PVL, PCL, LCLL, SNL, MXBL, LMCL, CPL, CPD, BW, DFH, DBL, PDL, LUCL, and IW (Table 2). The DFA analysis illustrated in the scatter plot shows that the three fish species were successfully grouped into three valid groups, where *T. tambra* is more similar to *T. douronensis* than *T. tambroides* (Fig. 2).

Based on the results of univariate and multivariate analysis, three fish species have been successfully grouped based on their morphometric characteristics. These results indicate that each species has specific characteristics that differentiate between fish species. These results also succeeded in revealing morphological differences in species even though the fish had high similarities. Similar results have also been shown in previous studies that morphometric characters

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can differentiate between fish species from the Genus *Barbonymus*, *Betta,* and the family Osphronemidae [13, 14, 15]. Furthermore, morphometric analysis can reveal intraspecies differences in fish based on different habitats [16].

Table 1. Univariate Analysis (ANOVA) Morphometric of Three *Tor* Species

No.	Morphometric characters	Species		
		Tor douronensis	Tor tambra	Tor tambroides
	ABL	3.01-10.13	3.90-8.44	4.43-12.23
		6.53±1.22^{b}	5.75±0.85^{a}	6.52±1.86^{b}
	BD	18.44-24.86	10.46-23.98	16.37-25.94
		20.71±1.45^{a}	21.02±2.20^{a}	22.55±2.19^{b}
	BW	9.13-12.60	9.62-12.75	9.28-24.08
		11.29±0.81^{ab}	10.96±0.75^{a}	11.88±2.98^{b}
	CPD	7.25-10.21	7.86-10.53	6.94-13.63
		8.74±0.66^{a}	9.09±0.47^{ab}	9.38±1.31^{b}
	CPL	8.82-15.69	9.78-14.97	9.22-16.32
		12.70±1.48^{a}	12.94±1.25^{a}	12.28±1.85^{a}
	DBL	7.75-13.58	8.88-13.52	7.83-13.33
		11.54±1.08^{b}	11.24±0.81^{ab}	10.77±1.40^{a}
	DFH	13.91-22.52	15.54-21.27	13.68-23.26
		18.35±1.89^{b}	18.23±1.54^{b}	16.66±2.34^{a}
	ED	3.81-8.40	4.59-7.34	3.54-7.29
		6.39±0.92^{b}	5.42±0.61^{a}	5.82±1.07^{a}
	HD	10.16-18.51	11.98-15.70	11.01-19.81
		15.62±1.75^{b}	13.44±0.66^{a}	15.34±2.25^{b}
	HL	14.83-23.99	16.86-20.33	13.64-22.89
		20.25±1.94^{c}	18.35±0.80^{a}	19.32±2.48^{b}
	HW	10.17-15.71	9.54-11.76	6.99-17.70
		11.45±0.82^{b}	10.45±0.54^{a}	11.05±2.10^{b}
	IW	6.27-10.32	5.72-8.81	5.63-11.66
		7.93±1.01^{c}	6.48±0.54^{a}	7.26±1.48^{b}
	LCLL	18.90-27.45	21.09-28.69	15.97-25.81
		24.85±1.81^{b}	24.57±1.49^{b}	22.45±2.59^{a}
	LMCL	7.61-14.65	7.28-10.79	6.29-13.16
		10.43±1.71^{b}	9.20±0.85^{a}	8.94±1.72^{a}
	LUCL	15.29-28.60	21.21-29.50	15.36-27.82
		24.27±2.55^{b}	25.21±1.92^{b}	22.11±3.41^{a}
	MXBL	5.51-10.42	4.54-8.78	3.65-9.76
		7.31±1.02^{b}	6.26±1.12^{a}	5.89±1.69^{a}
	PAL	47.97-63.70	53.66-71.33	42.54-64.47
		58.48±2.78^{a}	58.33±3.09^{a}	58.11±4.94^{a}
	PCL	14.97-20.23	15.64-20.23	10.71-18.64
		17.51±1.09^{b}	17.95±1.29^{b}	15.68±2.09^{a}
	PDL	36.66-42.95	35.66-42.57	33.34-44.79
		39.67±1.61^{b}	38.41±1.51^{a}	40.01±2.68^{b}
	PPL	30.12-45.50	34.38-40.24	34.02-47.09
		39.91±2.97^{b}	37.28±1.23^{a}	39.03-3.19^{b}
	PVL	11.69-17.98	14.03-18.58	10.19-17.85
		14.67±1.25^{b}	16.07±1.06^{c}	13.01±2.17^{a}
	SL	70.81-79.75	72.55-80.30	72.56-83.32
		75.76±2.47^{a}	76.26±2.01^{a}	76.91±2.99^{a}
	SNBL	5.39-12.09	3.28-10.13	4.51-9.88
		8.35±1.93^{b}	5.77±1.79^{a}	6.58±1.11^{a}
	SNL	3.15-6.68	4.54-8.58	2.84-6.26
		4.88±0.85^{b}	5.86±0.92^{c}	4.25±0.97^{a}

Note: Different superscripts showed significant differences (P<0.05) in the morphometric characters of the three *Tor* species.

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Key identification characters that can differentiate between *Tor* species based on this study include APL, BD, BW, CPD, DBL, DFH, ED, HD, HL, HW, IW, LCLL, LMCL, LUCL, MXBL, PCL, PDL, PPL, PVL, SNBL, and SNL. This is because the value of each morphometric character is significantly different. Other studies have also revealed that identification between *Tor* species can be done through osteological structures [6]. Although several studies on the genetics of this fish have been revealed [17, 9, 18, 19], morphological identification is a necessity carried out by researchers in classifying the most basic [20]. Morphological identification including morphometric measurements has the advantage that it can be done directly, does not require high-tech laboratory equipment, is inexpensive, and is relatively easy [13].

Table 2. Eigenvalue, % of Variance, and Matrix Structure of Three *Tor* Species

Variable	Function I	Function II
Eigenvalue	2.50	1.39
% of Variance	64.1	35.9
SNBL	0.397*	0.213
ED	0.301*	0.119
PPL	0.289*	0.020
HD	0.249*	0.017
ABL	0.180*	-0.056
HL	0.175*	0.010
SL	0.133*	-0.046
HW	0.066*	-0.020
BD	0.058*	-0.055
PAL	0.011*	0.009
PVL	-0.332	0.497*
PCL	-O.143	0.479*
LCLL	-0.007	0.428*
SNL	-0.348	0.352*
MXBL	0.204	0.323*
LMCL	0.018	0.289*
CPL	-0.175	0.276*
CPD	-0.094	-0.237*
BW	-0.107	-0.224*
DFH	0.064	0.218*
DBL	-0.041	0.198*
PDL	0.032	0.132*
LUCL	-0.026	0.116*
IW	0.016	0.068*

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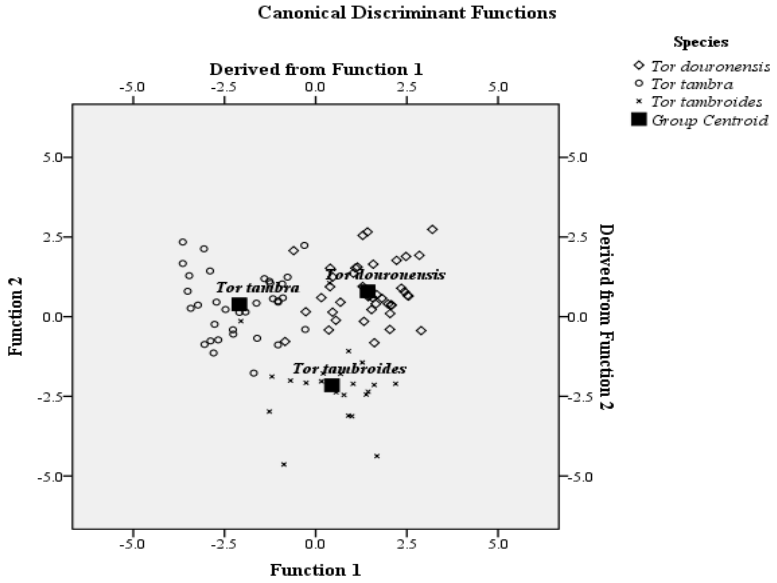

Figure 2. Scatter Plot of Morphometric Characters Of Three *Tor* Species

Conclusion

Based on the results of univariate and multivariate analysis, three fish species have been successfully grouped based on their morphometric characteristics. The morphometric characters that were not significantly different (P>0.05) included CPL, PAL and SL, while the morphometric characters that were significantly different (P<0.05) included APL, BD, BW, CPD, DBL, DFH, ED, HD, HL, HW, IW, LCLL, LMCL, LUCL, MXBL, PCL, PDL, PPL, PVL, SNBL, and SNL. Multivariate analysis produces two functions, where functions I and II have eigenvalues reaching 2.50 and 1.39 with the % of variance values of each function reaching 64.1% and 35.9%.

Acknowledgments

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Ginkgo biloba extract and exercise on brain-derived neurotrophic factor (bdnf) levels

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Abstract. *Ginkgo biloba extract contains antioxidants, antivirals, and anti-inflammatory. Ginkgo biloba extract also has a good effect on CNS (central nervous system) function and as a neuroprotective. Exercise can increase levels of Brain Derived Neurotrophic Factor (BDNF) and neurotransmission, as well as produce beneficial effects on mood and cognitive function in individuals of all ages. BDNF is one of the neuroprotective mechanisms, because it can promote neurite growth, nerve cell proliferation and differentiation, and prevent granular cell apoptosis. The relationship between physical activity and neurogenesis suggests that physical activity can increase cell proliferation and promote nerve cell survival. The purpose of this study was to determine the effect of Ginkgo biloba extract and exercise as neuroprotective with increased BDNF levels. The subjects of the study used male white rats totaling 20, aged 2-3 months, body weight 180-200 gr. The results showed an increase in BDNF levels after administration of Ginkgo biloba extract and exercise.*

Keywords : Antioxidant, BDNF, exercise, ginkgo biloba, neuroprotective

Introduction

These changes in the brain such as neurological disorders can affect cognitive decline, progressive reduction in neurotrophic levels, changes in cerebrovasculature, and decreased neurogenesis [1].

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Based on research conducted by the Global Burden of Disease, it is known that one of the biggest public health problems is neurological disorders. This happens in several countries ranging from developing countries to developed countries, there is even no policy in an effort to deal with it.
It has now been found that loss of nerve function due to neurological disorders can be corrected by nerve regeneration. Therefore, fast and appropriate efforts are needed in the treatment of neurological disorders, as well as good prevention efforts so that they can reduce the prevalence of neurological disorders in the community [2].

Therefore, fast and appropriate efforts are needed in handling neurological disorders, as well as good prevention efforts so that they can reduce the prevalence of neurological disorders in the community. In Ginkgo biloba extract in addition to antioxidants, it also contains antiviral, anti-inflammatory, and anticarcinogenic. Ginkgo biloba extract also has a good effect on CNS (central nervous system) function. Physical activity such as swimming plays an important role in maintaining a healthy lifestyle, as it supports the cardiovascular system, immune system and metabolism as well as modulates the internal milieu of the brain [3].
Physical activity has been reported to increase levels of Brain Derived Neurotrophic Factor (BDNF) and neurotransmission, as well as produce beneficial effects on mood and cognitive function in individuals of all ages [4]. BDNF is one of the neuroprotective mechanisms, because it can promote neurite growth, nerve cell proliferation and differentiation, and prevent granular cell apoptosis. The relationship between physical activity and neurogenesis, suggests that physical activity can increase cell proliferation and promote nerve cell survival [5].
The purpose of this study was to determine the effect of Ginkgo biloba extract and exercise as neuroprotective.

Materials and Methods

Ethical Approval

Animal Research Ethics Committee Faculty of Mathematics and Natural Sciences - University of North Sumatra (Animal Research Ethics Committees/AREC) No. 0260/KEPH-FMIPA/2023.

Subject

The subjects of the study used male white rats totaling 20, aged 2-3 months, body weight 180-200 gr.

Research Procedure

Experimental animals were divided into 2 groups, namely: Group P1: Rats were given Ginkgo biloba extract 10 mg / rat orally by dissonde and swimming activities frequency 3x a week, duration 1 hour, for 2 weeks. Group P2: Rats were only given swimming activities, frequency 3x a week, duration 1 hour, for 2 weeks. Then the animal was executed under anesthesia using chlorophom to draw blood from the heart for BDNF examination. BDNF level examination is carried out using a spectrophotometer with the ELISA method.

Results and discussion

The results showed there was a significant increase in BDNF levels between before and after treatment in both groups. The results of this study showed no significant difference in BDNF levels

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between the P1 and P2 groups, but BDNF levels in the P1 group given swimming activities and Ginkgo Biloba extract (P1 group) were higher than the swimming group without Ginkgo Biloba extract (P2 group).

Table 1. Average amount of Brain Derived Neurotrophic Factor (BDNF)

Variable	P1 Group Mean ± Sd	P2 Group Mean ± Sd	p
BDNF			
Pre-test	0.799±0.099	0.737±0.141	0.504
Post-test	1.066±0.250	1.047±0.079	
t-test	0.007	0.000	

Increased BDNF levels occur because Gingko biloba extract contains powerful antioxidants in protecting vascular endothelial cells from oxidative stress by eliminating free radicals. It can also increase cerebral and peripheral blood flow through modulating blood flow, decreasing vascular permeability and activating the nervous system directly through neurons. So that Gingko biloba extract has an effect as a neuroprotective or neuroprotective in the CNS (central nervous system) for brain health. Lower BDNF levels in the P2 group than in the P1 group are a form of brain adaptation in maintaining homeostasis.

Gingko biloba extract contains powerful antioxidants in protecting vascular endothelial cells from oxidative stress by eliminating free radicals. It can also increase cerebral and peripheral blood flow through modulating blood flow, decreasing vascular permeability and activating the nervous system directly through neurons. So that Gingko biloba extract has an effect as a neuroprotective or neuroprotective in the CNS (central nervous system) for brain health [6].

The results of this study are in line with the results of previous studies that Gingko biloba extract can fight free radicals, increase neurogenesis (growth of nerve cells), stabilize cell membranes, increase neurotrophic factors derived from the brain, and also adapt to the environment needed during the process of stem cell differentiation into nerve cells [7].

Previous research results found that Ginkgo biloba extract has the potential to be used in improving cognitive function, activities of daily living, and clinical assessment in patients with mild cognitive impairment or Alzheimer's [8]. Recent studies have also provided evidence that Ginkgo biloba has benefits and is safe to use in the treatment of acute cerebral infarction because it can increase positive outcomes and provide neuroprotective effects [9].

Conclusion

Gingko biloba extract has neuroprotective effects in the CNS (central nervous system) for brain health.

Acknowledgments

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Analysis of the secondary metabolite content of the ethanol extract of Asystasi gangetica leaves

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Abstract. *This study aims to determine the secondary metabolite content of Asystasia gangetica leaves. Asystasia gangetica leaves were macerated with ethanol solvent. The maceration results were then analyzed using a Gas Chromatography-Mass spectrophotometer (GC-MS). The results of the GCMS analysis were evaluated using the MASLAB program. Data obtained from the GCMS tool were then further analyzed using the PubChem NCBI database software (https://pubchem.ncbi.nlm.nih.gov/) and online PASS. The results of the GC-MS analysis showed that there were 25 bioactive compounds in Asystasia gangetica leaves. The results of this study can be used as a basis for a development program for the potential utilization of bioactive compounds in Asystasia gangetica leaves as antibacterial, antifungal, and antiviral. In future research, it is necessary to analyze other plant parts and make comparisons to complete the available database*.

Keywords: leafe extract, Phytochemical, Secondary Metabolyte, Antibacterial, Antifungal, Antiviral

Introduction

Asystasia gangetica is often referred to as breech fig, Israeli grass, and china violet [1]. *A. gangetica* is a weed plant that is often used as a source of forage for animal feed and is easily found

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in yards, roadsides, gardens, vacant land, and open fields. *A. gangetica* is a type of grass that is often suspected to be a nuisance grass in oil palm and rubber farms in Indonesia, but *A. gangetica* grass has several benefits, namely healing wounds, muscle spasms, and coughing [2].

Asystasia gangetica leaves have greater nutrient levels compared to stem organs and other organs. Based on previous research, phytochemical tests of ethanol extract of *A. gangetica* leaves obtained active substances in the form of alkaloids, flavonoids, steroids, and saponins [3]. The secondary metabolite compounds obtained are bioactive components that have the potential to be antidiarrheal and antibacterial [4]. Another research showed that the whole extract of *A. gangetica* plants using ethyl acesate solvents, methanol, and hexane showed an influence on the growth of *Escherichia coli* and *Stapylococcus aureus* which means that *A. gangetica* plants can be used as antibacterial ingredients to inhibit *Escherichia coli* and *Stapylococcus aureus* bacteria [5].

A. gangetica has good nutritional content and protein content. A. gangetica leaves have higher nutrient levels than the stem. A. gangetica in Indonesia is often suspected to be a destructive grass in oil palm and rubber farms, but this grass has many benefits, namely healing muscle spasms, wounds, and coughs [6]. *A. gangetica* is found in North Sumatra Province which is used for food for cattle, goats, and cattle. *A. gangetica* in Marihat Dolok area is referred to as spinach-bayman which is used as cattle feed for cattle and goats, while in Tiga Juhar area, *A. gangetica* is referred to as wild grass is used as rabbit vegetables and animal feed for cows.

A. gangetica leaves have secondary metabolite compounds, namely alkaloids, flavonoids, saponins, and steroids [7]. Alkaloids are secondary metabolite compounds that have polar properties so that alkaloids can dissolve in polar solvents such as ethanol. Alkaloid compounds can be antibacterial agents, namely by damaging the peptidoglycan-forming elements of bacterial cells which result in parts of the cell wall not forming perfectly, and bacterial cells can die [8].

Flavonoids can be attracted to polar solvents because flavonoids are compounds that have polar properties. In its mechanism of action as an antibacterial, flavonoid compounds can slow down the cytoplasmic membrane in carrying out its functions, aerobic metabolism, and nucleic acid synthesis so that cells do not have energy and cause cells to lysis.

Saponin compounds have semi-polar properties so that they can dissolve in polar and nonpolar solvents. Saponins that act as antibacterial can cause damaged proteins and enzymes found in cells. Saponins have active compounds in their coating that resemble detergents so that they can damage membrane permeability and lower the pressure of the bacterial cell wall layer. Through the outer membrane of the cell, saponin compounds diffusion and the cell wall will bind to the cytoplasmic membrane so that it can inhibit the stability of the cell membrane and cause the cytoplasm to leak and the cell to die.

Based on the description above, further studies are needed related to the compounds found in the leaf extract of *Asystasia gangetica*. The discovery of specific compounds from ethanol extract of *Asystasia gangetica* leaves will be the basis of research in assessing the potency of all identified compounds.

Methodology

The research was carried out at the Microbiology Laboratory and Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, State University of Medan on Jalan Willem Iskandar, Pasar V Medan Estate, Percut Sei Tuan District, Deli Serdang District, North Sumatra. This research will be conducted from February to July 2023.

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Population

The population in this study is *A. gangetica* leaves obtained from vacant land on Jl. Nilam 21, Prumnas Simalingkar A, Medan Tuntungan District, Medan, North Sumatra, Indonesia.

Sample

The samples in this study were fresh green leaves of *A. gangetica* from sequence number 3 from leaf shoots to sequence number 7 obtained from vacant land on Jl. Nilam 21, Prumnas Simalingkar A, Kec. Medan Tuntungan, Medan, North Sumatra.

Asystasia gangetica Leaf Collection

A. gangetica leaves are obtained from vacant land on Jl. Nilam 21, Prumnas Simalingkar A, Medan Tuntungan District, Medan, North Sumatra. A. gangetica leaf sampling by picking fresh green leaves from sequence number 3 from leaf shoots to sequence number 7. leaf number 3 from the top of the leaf has gone through a physiological maturation process and already has maximum metabolite compounds [9].

Asystasia gangetica leaf preparation

A. gangetica leaves that have been collected are cleaned with running water until clean and then dried in a room that is not exposed to sunlight for ±7 days. Aerated-dried leaves of A. gangetica are dried again using an oven at 50ºC within 2 hours. Oven drying is carried out to reduce the percentage of water on the leaves to avoid the presence of pathogenic microbes and fungi when stored [10]. The initial parameter of stopping the drying stage is leaves that can be crumbled [11]. The leaf sample is mashed with a blender until it is simplisia and then sifted using a sieve. The purpose of sieving is to obtain smaller simplisia particles to facilitate the extraction process and to make the size of the simplisia used uniform [12]. Finer simplisia can cause the surface area of the simplisia to be larger until there are also many components contained in the simplisia that can be withdrawn by the solvent. The simplisia obtained must meet the moisture content standardization. Simplisia standardization based on the Indonesian Herbal Pharmacopoeia Edition III that the standardization of water content is not more than 10% (<10%) [13].

Determination of Moisture Content Standardization

Standardization of moisture content is carried out by heating porcelain dishes in an oven for 30 minutes at a temperature of 105 ° C, after heating porcelain dishes are cooled in a desiccator device and then measured in weight. A total of 2 gr of simplistic leaves of *A. gangetica* were put in a porcelain dish and then put in the oven for ± 3 hours at a temperature of 105 ° C. A porcelain dish containing simplisia cooled in a desiccator and then measured in weight. The requirement for determining the standardization of leaf moisture content is not less than 10% (≤10%).

Manufacturing of Asystasia gangetica Leaf Ethanol Extract

The extract is obtained by maceration. Simplisia leaves of *A. gangetica* as much as 300 g are put into Erlenmeyer, then soaked in 600 ml of ethanol p.a with a solvent ratio of 1: 2. The extraction process is carried out for 5 days and stirred once every 6 hours within 5 minutes. The extract is filtered with filter paper to separate it from the pulp, then soaked again in the same ratio for 3 days.

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The residue resulting from the second maceration was macerated again in a solvent ratio of 1:1 for 3 days. The extract results are obtained, combined and evaporated using a rotary vacuum evaporator at a temperature of 50ºC until a thick extract is formed.

Qualitative Test of Ethanol Extract of Asystasia gangetica leaves

The test of secondary metabolite compounds was carried out on a qualitative scale using color reagents to determine metabolite compounds in the form of alkaloids, saponins, flavonoids, steroids, and tannins

Gas Chromatography-Mass Spectrometry (GC-MS) Test

The GC-MS technique is used to identify phytochemical compounds contained in a plant. GC-MS is a process of gas chromatography which is a process of detecting volatile substances/compounds, while mass spectrophotometers are the process of identifying compounds through molecular weight and determining their molecular formula. The GC-MS method is particularly suitable for volatile essential oils

Results and discussion

***Qualitative Test Results Secondary Metabolites of A. gangetica* Leaves**

The leaves of *A. gangetica* used in this study were obtained from vacant land on Jl. Nilam 21, Perumnas Simalingkar A, Medan Tuntungan District, North Sumatra. The result of drying the wet weight of 5.5 kg of A. gangetica leaves obtained *A. gangetica* leaf simplisia powder , which is as much as 800 g.

The simplisia that has been obtained is then carried out by a standardization test of the percentage of water. The result of standardization of the percentage of water powder leaves o*f A. gangetica is 9.5*%. Simplisia that has met the water content standardization, then the maceration stage is carried out using a ratio of 1: 2 with ethanol solvent p.a obtained thick extract of *A. gangetica leaves as* much as 31.08 gr. The thick extract obtained is then calculated in yield to determine the results of the extract obtained from the maceration process. The yield yield of ethanol extract of *A. gangetica* leaves obtained was 10.36% (figure 1).

Secondary metabolite assays are performed by adding reagents or reagents to test tubes containing *A. gangetica leaf simplisia powder.* Secondary metabolite tests are alkaloids, saponins, flavonoids, steroids, and tannins (table 1). The secondary metabolite content of Asystasia gangetica ethanol extract shows potential activity in inhibiting bacterial growth, antioxidants, and others

Figure 1. *A. gangetica leaf preparation*

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Table 1. Results of secondary metabolites of *A. gangetica* leaves

Test	Reagent	Reaction Results	Information
Alkaloids	Mayer	+	There is a white precipitate
	Dragendroff	-	No orange-red deposits
Saponins	Water + HCl concentrated	+	There is foam
Flavonoids	Concentrated HCl + Mg	+	There is an orange color
Steroids	Lieberman Bouchard	+	There is a dark brown color
Tannins	FeCl3 1%	+	There is a blackish-green color

From the table above, it is known that *A. gangetica* leaves show secondary metabolite content with alkaloid tests using Mayer reagents, saponin tests, flavonoid tests, steroid tests and tannin tests. Qualitative tests for secondary metabolites are important for several reasons in the field of biology, pharmacology, and related sciences. Secondary metabolites are organic compounds that are not directly involved in the growth, development, or reproduction of an organism.

In alkaloid tests, a white precipitate may form as a result of the reaction between alkaloids and specific reagents. The formation of a white precipitate can be indicative of the presence of alkaloids in a given sample. Alkaloids are a group of naturally occurring organic compounds that often contain basic nitrogen atoms and are commonly found in plants. The presence of foam in a saponin test is characteristic and indicative of the presence of saponins in a given sample. Saponins are a diverse group of natural compounds found in various plant species, and they have surfactant properties, meaning they can produce foam when agitated in the presence of water.

GCMS Test Results

GC-MS is particularly effective for volatile and semi-volatile compounds. Based on the GC-MS test results, the ethanol extract of Asystasia gangetica obtained 25 compounds. The distribution of these compounds can be seen in the table below (table 2). Based on the results of GC-MS analysis, 25 compounds were obtained. The distribution of these compounds is from various types of groups, such as steroids, vitamin E, terpenoids, flavonoids, unsaturated fatty acids, fatty acids, and phenols. Based on these data, the presence of these compounds can potentially be antiviral, antioxidant, or antimicrobe. The potential of these compounds in life needs to be in vitro studies to determine the potential of *A. gangetica ethanol extract* by its potential. *Asystasia gangetica* can be used as an antimicrobial [14-15] and antioxidant [16].

Flavonoid compounds as antibacterial can denature bacterial cell proteins so that they can disrupt the bacterial cell layer. Flavonoids can inhibit cytoplasmic membrane function, aerobic metabolism, and nucleic acid synthesis so that cells do not have energy and cause cells to become lysis. The way steroids work when inhibiting the development of bacteria is that they react with the lipid layer, which can cause leakage in bacterial lysosomes.

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Table 2. GC-MS Test Results of *Asystasia gangetica* ethanol extract

No	Peak	RT	Peak Area %	Compound Constituents
1	14	20,49	0,263	Neophytadiene
2	7	16,232	0,565	Octadecanal
3	15	21,981	0,666	Neophytadiene
4	13	18,801	0,719	Ethyl stearate
5	10	18,149	0,853	1 Hexadecen-3-ol, 3, 5, 11, 15-tetramethyl
6	17	24,422	0,997	Stigmastan-3,5-diene
7	19	25,901	1,277	bis(2-cyanobenzothiazo-6-yl) sulfone
8	2	11,013	1,294	2-Vinyl-2, 3-dihydrobenzofuran
9	9	16,951	1,782	Ethyl Palmitate
10	1	6,458	2,06	Levoglucosenone 6, 8-Dioxabicyclo
11	5	15,85	2,159	Neophytadiene
12	18	25,125	2,37	DL-alpha-Tocopherol
13	21	27,036	2,434	Stigmastan-3,5-diene
14	8	16,663	3,047	Hexadecanoic acid/palmitic acid
15	16	23,92	3,076	2, 6 ,10, 14, 18, 22-Tetracosahexaene, 2, 6, 10, 15, 19, 23-hexamethyl
16	3	11,87	3,273	Methyl alpha-D-Galactopyranoside
17	6	15,85	3,814	3, 7, 11, 15-tetramethyl-2-hexadecen-1-ol
18	11	18,376	4,665	9, 12, 15-octadecatrienoic acid methyl ester
19	20	26,351	5,946	Gamma Tocopherol
20	23	29,139	6,19	Campesterol
21	12	18,604	7,192	9, 12, 15-octadecatrienoic acid ethyl ester
22	4	15,661	10,145	Neophytadiene
23	22	27,466	10,358	DL-alpha-Tocopherol
24	24	29,71	11,742	Stigmasterol
25	25	30,819	13,115	Clionasterol

Conclusion

Based on the results of research that has been done, it was obtained that there are 25 compounds based on the results of GC-MS from ethanol extract of *Asystasia gangetica*. Of all the compounds that have been identified, they can be classified into steroid compounds, vitamin E, terpenoids, flavonoids, unsaturated fatty acids, fatty acids, and phenols that have the potential as antivirals, antioxidants, antimicrobials.

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Phytochemical analysis of ethanol extract of *urena lobata* leaves

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Abstract. *This study aims to determine the phytochemical content of the ethanol extract of Urena lobata leaves, especially the content of secondary metabolites. Urena lobata leaves were obtained from North Sumatra. The method in this study was to macerate the ethanol extract of urena lobata leaves, then a phytochemical screening test was carried out with several suitable reagents and followed by a phytochemical test with GCMS. The results showed that there were 43 compounds from the ethanol extract of Urena lobata leaves. These results will be further developed to identify compounds that have potential as antimicrobial, antifungal and antiviral agents. Identification of the potential of the ethanol extract of Urena lobata leaves was carried out using an in silico approach.*

Keywords: leafe extract, Phytochemical, Secondary Metabolyte, Antibacterial, Antifungal, Antiviral

Introduction

Pulutan plants, which are herbal plants classified under the Malvaceae family, have yet to gain significant traction within the community as antidiarrheals. The leaves of *U. lobata* have been documented as a traditional medicine for several ailments including as tonsil inflammation, influenza, malaria, cough, rheumatism, vaginal discharge, bleeding wounds, swelling, and ulcers [1]. In the study conducted [2], it was found that pulutan plants possess potential medicinal

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properties, including antidiarrheal, rheumatism-relieving, colic-alleviating, toothache-relieving, wound-healing, and antimalarial effects. The leaf is commonly employed for medicinal purposes because to its high concentration of secondary metabolite chemicals, which are believed to possess greater therapeutic value compared to the stems or roots. Furthermore, the leaf component represents a readily accessible and abundant source, serving as a repository for photosynthates believed to possess therapeutic qualities [3].

Pulutan has been identified to possess medicinal properties that may be beneficial in treating many health conditions such as cough, influenza, malaria, inflammation of the tonsils, ulcers, bleeding wounds, fractures, rheumatism, vaginal discharge, swelling, and snake bites. The extract derived from Pulutan leaves (*U. lobata*) exhibits promising bioactivity, demonstrating antibacterial, antioxidant, antifungal properties, as well as the ability to impede the proliferation of cancer cells. Pulutan (*U. lobata*) is employed in traditional medicine due to its possession of secondary metabolite chemicals and bioactive properties. The pulutan leaves' methanol extract comprises various chemical compounds, namely tannins, terpenoids, saponins, cardioglycosides, and alkaloids. These compounds possess the capability to inhibit the proliferation of bacteria such as *Enterococcus species, Pseudomonas aeruginosa, Staphylococcus aureus, Klebsiella sp, and Escherichia coli* [4]. The study conducted by [5] revealed that the ethanol extract and simplisia of pulutan leaf (*U. lobata*) contain many secondary metabolites, including flavonoids, monoterpenes, quinones, tannins, steroids, and phenolics. The aforementioned compounds possess bioactive properties and exhibit potential as antibacterial agents.

The ethanol extract of *Urena lobata* leaves demonstrates the potential to inhibit the proliferation of antibiotic-resistant *Escherichia coli* and *Staphylococcus aureus* bacteria. The solvent of choice for the extraction process is ethanol of analytical grade. According to a study conducted by [6], ethanol is commonly employed as a solvent due to its universal nature, efficient absorption capabilities, ready availability, selectivity, non-toxicity, and high irritability. These properties enable ethanol to effectively extract a wide range of molecules, including those that are polar, semipolar, and non-polar.

The Dayak community refers to certain plants as "pulutan" and utilizes them for the purpose of treating abdominal pain resulting from various disease factors that have persisted within the stomach for an extended period of time. The utilized component in this therapeutic intervention consists of a root measuring two centimeters. The procedure involves selecting only 3-5 roots, which are subsequently subjected to a thorough washing and a one-hour water soaking period prior to consumption [7]. The indigenous community known as the Kulawi tribe, residing in the town of Mataue in Central Sulawesi, refers to the *Urena lobata* plant as pulutan. This particular plant is utilized for its medicinal properties in the treatment of leucorrhoea. The recommended procedure involves taking two handfuls of pulutan leaves and ensuring they are well washed. Subsequently, these leaves should be boiled in an adequate amount of water until the water reaches a slightly warm temperature. This water can then be used for cleansing the female genital area or for cleaning during urination. It is advised to follow this practice for a duration of seven days, as suggested by [8]. In Entogong village, located in the Kayan Hulu District of Sintang Regency, the indigenous term used to refer to the pulutan plant (*U. lobata*) is Jelumoang. The leaves of this plant are commonly utilized in traditional medicine for the purpose of alleviating stomach pain. The conventional method involves boiling the leaves and thereafter consuming the resulting infusion. Based on the indigenous population of West Sulawesi, the botanical term for pulutan plants is

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Lelupang. These plants possess medicinal properties, as their leaves are employed in the treatment of boils. The therapeutic approach involves the application of Lelupang leaves into the affected area, resulting in the formation of ulcer eyes [9].

In light of early research highlighting the several advantages associated with *Urena lobata* leaves, it is imperative to undertake a comprehensive investigation pertaining to the chemical composition of these leaves. Understanding the chemical composition of Urena lobata leaves is crucial for future investigations pertaining to the chemicals present in these leaves.

Methodology

The proposed investigation is scheduled to take place between February and June 2023 at the Microbiology Laboratory of the Department of Biology, Faculty of Mathematics and Natural Sciences (FMIPA), Medan State University. The laboratory is located at Jl. Williem Iskandar Pasar V Medan Estate, Percut Sei Tuan, Deli Serdang, North Sumatra.

The population under investigation in this study employed the utilization of pulutan leaves, scientifically known as *Urena lobata*. The research sample refers to the subset of individuals or objects that are selected from a larger population to participate in a study.

The study utilized pulutan leaf extract (*U. lobata*) as the sample, which possesses desirable characteristics such as resistance to caterpillars and pests, a vibrant green color, and the separation of petioles from the leaves [10]. The specimen was obtained from an uninhabited area located in Jl. Pendidikan, Siborutorop Village, Paranginan District, Humbang Hasundutan Regency, North Sumatra Province.

The process of sample preparation and simplisia making

A quantity of 9 Kg of pulutan leaves (*U. lobata*) were collected from an unoccupied area located on Jl. Pendidikan, Siborutorop Village, Paranginan District, Humbang Hasundutan Regency, in the province of North Sumatra. The pulutan leaves included in this study were carefully selected to ensure high quality. Specifically, the leaves were sourced from the same kind found in Humbang Hasundutan. These leaves were chosen based on their desirable characteristics, such as being free from caterpillar or pest damage, exhibiting a vibrant green color, and having their petioles cut. The harvested Pulutan leaves (*U. lobata*) undergo a washing process using running water to ensure cleanliness. Subsequently, the leaves are dried in a room that is shielded from direct sunlight for a duration of 5 days. The pulutan leaves, specifically ± *U. lobata*, undergo a drying process in which they are exposed to an oven temperature of 500C for a duration of 2 hours. This method is employed to optimize the efficiency of the drying procedure. The initial parameter for halting the drying process is indicated by the presence of pliable leaves [11]. Subsequently, the provided sample is subjected to blending in a mechanical device until it reaches the state of a powdered substance devoid of moisture. The objective of producing a fine powder is to optimize the extraction process by increasing the surface area. Smaller particle sizes result in a larger surface area. Consequently, the efficacy of the sample's interaction with the solvent will be enhanced [12].

The process of doing a phytochemical screening Phytochemical screening entails the utilization of a qualitative scale alongside color reagents to ascertain the presence of secondary metabolite components, such as alkaloids, saponins, flavonoids, steroids/terpenoids, and tannins.

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Results and discussion

The results of the extraction carried out using the maceration method with a ratio of 1:3, namely 300 grams of simplicia with 900 ml of ethanol p.a., 28.45 g of thick extract was obtained which had a blackish green color as shown in Figure 1

.

Figure 1. Extraction of pulutan leaves (U. lobata); a) filtering process from maceration, b) pulutan leaf extract in a rotary vacuum evaporator, and c) thick extract

Characteristics of the extract obtained is that it is a thick extract, blackish green in color with a strong odor. Data on simplicia results, water content and yield from the extraction process of *Urena lobata* leaves are presented in table 1:

Table 1. The concept of simplicity and its ability to produce desired outcomes

The materials employed	Simple density	Water level	Extract weight	percent yield
Urena lobata	300 g	6%	28,45 g	9,5 %

Ethanol extract of *Urena lobata* leaves was carried out using a maceration process. After GC-MS was carried out, 43 compounds were obtained. The results of the GC-MS analysis obtained are in the form of names of phytochemical compounds accompanied by retention time (RT), coverage area, reference, CAS (Chemical Abstracts Service) number and qualitative (Qual). Apart from that, the results of the GC-MS analysis are also equipped with a chromatogram of the analysis results which includes the area, retention time and also the abundance (abundance) needed to identify the compound phytochemicals. Based on these results, the ethanol extract of Urena lobata leaves consists of flavonoids, alkaloids, steroids, so it is possible that the potential of the ethanol extract of Urena lobata leaves can be antibacterial, antiviral and antioxidant.

Plants have two types of metabolite compounds, namely primary and secondary metabolites [13]. Primary metabolites are used by plants for growth, while secondary metabolites do not

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play a direct role in plant growth. Secondary metabolites are produced by plants in certain amounts under stress conditions. Examples of secondary metabolites include antibiotics, pigments, toxins, effectors of ecological competition and symbiosis, pheromones, enzyme inhibitors, immunomodulation agents, receptor antagonists and agonists, pesticides, antitumor agents, and animal and plant growth promoters [14].

Table 2. Results of *Urena lobata* ethanol extract GC-MS analysis

No	RT	Peak Area %	Name of Compound
1	25,413	0,168	15,16-Epoxylabda-7,13(16),14-triene
2	19,964	0,236	Docosanol
3	20,556	0,247	Bis(2-ethylhexyl) adipate
4	24,127	0,283	1,6,10,14,18,22-Tetracosahexaen-3-ol
5	24,232	0,313	2, 7-Anhydro-7-(amino)-4, 5, 7-trideoxy-1, 3-di-O-methyl
6	22,826	0,314	Ethyl 14-methyl-hexadecanoate
7	26,579	0,355	1,2,4-Oxadiazole, 3-(1,3-benzodioxol-5-yl)-5
8	17,595	0,356	4-Oxazolecarboxylic acid, 4,5-dihydro-2-phenyl, 1-methylethyl ester
9	20,502	0,36	Methyl 19-methyleicosanoate
10	25,888	0,368	Solanesol
11	23,592	0,475	Ethyl tetracosanoate
12	22,078	0,518	Nonadecanoic acid ethyl ester
13	35,879	0,593	4-epi-Friedelin
14	24,471	0,651	Eicosane
15	25,126	0,656	Delta tocopherol
16	44,336	0,71	Heptadecene-(8)-carbonic acid-(1)
17	26,749	0,715	Eicosane
18	38,608	0,887	1-Dimethyl (phenyl) silyloxypentane
19	33,785	1,043	Stigmast-4-en-3-one
20	26,169	1,139	Beta tocopherol
21	15,66	1,142	3, 7, 11, 15-Tetramethyl-2-hexadecen-1-ol
22	18,799	1,177	Ethyl stearate
23	27,04	1,339	Stigmastan-3,5-diene
24	31,213	1,434	3 beta-Hydroxy-8,11,13(14)-abietatetraen-18-oic acid
25	36,868	1,438	Neophytadiene
26	18,139	1,454	3,7,11,15-Tetramethyl-2-hexadecen-1-ol
27	31,587	1,653	Beta amryn
28	29,129	1,832	Campesterol
29	15,849	1,893	3, 7, 11, 15-Tetramethyl-2-hexadecen-1-ol
30	26,354	2,048	Gamma tocopherol
31	16,949	2,362	Ethyl palmitate
32	18,595	3,083	Ethyl linolenate
33	31,968	3,137	Ethynyl (1R,2R,5S)-5,8,8-trimethylbicyclo
34	33,652	3,66	Fernene
35	23,923	3,684	2,6,10,14,18,22-Tetracosahexaene
36	16,674	3,793	Hexadecanoic acid/palmitic acid
37	34,386	3,945	Fern-7-en-3 beta-ol
38	18,378	4,455	9, 12, 15-Octadecatrienoic acid, methyl ester
39	32,555	4,506	Lupeol
40	29,693	4,687	Stigmasta-5,22-dien-3-ol
41	15,408	5,846	Neophytadiene
42	27,482	11,882	DL-alpha-Tocopherol
43	30,827	19,161	Gamma sitosterol

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Conclusion

The number of phytochemical compounds obtained from jamblang leaf essential oil was 43 compounds obtained from the ethanol extract of Urena lobata in a ratio of 1:3. Urena lobata's secondary metabolites consist of flavonoids, tannins, and alkaloids.

Acknowledgments

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Effect of ethanol extract of leaf of *Biden spilosa* (L) on the hematological profile of alcohol-greated white rats

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Abstract. *Alcohol consumption affects the physiology of the body including blood. The purpose of this study was to examine the effect of the ethanol extract of Bidens pilosa leaves (EEB) on the hematologic profile of white rats consuming alcohol. This study used 24 adult male rats and divided them into four treatment groups. The group was K0 rats given 0.5% CMC, K1, rats given alcohol 7.9 ml/kg body weight, K2 rats given EEB 300 mg/kg body weight and alcohol 7.9 ml/kg body weight, K3 rats given EEB 600 mg/kg body weight and alcohol 7.9 ml/kg body weight. EEB was given every day for 42 days,*

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alcohol was given 2 hours after EEB administration every day for 42 days. Alcohol and EEB were administered orally using a gastric tube. On the 43rd day, the rats were weighed and then anesthetized and killed by neck dislocation to take blood. Parameters observed were red blood cells, Hemoglobin, Hematocrit, MCV, MCH, MCHC, Platelets, RDW-CV, PDW, MPV and PCT using a Hematology Analizer. The results showed that alcohol significantly ($p<0.05$) decreased red blood cells, hemoglobin, hematocrit, platelets and PCT. Giving EEB to both K2 and K3 increased red blood cells, hemoglobin, hematocrit and platelets significantly compared to the K1 group. EEB and alcohol had no significant effect on changes in MCV, MCH, MCHC. RDW-CV, PDW and MPV were not significantly different in the K1 group. EEB in K2 and K3 treatments increased RDW-CV, PDW, MPV and PCT

Keywords: Bidens pilosa, alcohol, hematology profile

Introduction

Alcohol consumption can cause problems with several body organs. Several research results explain that chronic alcohol consumption can cause kidney problems [1], liver damage [2] and has effects on bone marrow and precursors of blood cells [3]. Alcoholics frequently have defective red blood cells that are destroyed prematurely, possibly resulting in anemia. Alcohol also interferes with the production and function of white blood cells, especially those that defend the body against invading bacteria. Consequently, alcoholics frequently suffer from bacterial infections [4]. Chronic heavy alcohol use can cause abnormalities in the blood, leading to anaemia (low haemoglobin, the component of blood that carries oxygen around the body) and low platelets (platelets help prevent bleeding) [5].

Haematological parameters are important in establishing the body's functional status. Red blood cell and factors relating to it are major indices for evaluating circulatory erythrocytes, these entities are significant in the diagnosis of anaemia and also serve as useful indices of the bone marrow's capacity to produce RBC particularly in mammals [6,7]. A complete blood count (CBC) is a hematological examination carried out to evaluate blood cells in the body, including the red blood cell (erythrocyte) component. Apart from counting the number of red blood cells, there are other components that need to be checked through laboratory tests, namely mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), dan mean corpuscular hemoglobin (MCH).

Mean corpuscular volume (MCV) is an analysis method in the laboratory that is carried out to measure the volume and average size of erythrocytes or red blood cells as a whole. This examination is carried out by multiplying the hematocrit percentage by ten, then dividing by the number of erythrocytes (red blood cells) in the body.

Mean corpuscular hemoglobin (MCH) is a calculation of red blood cells found in laboratory examination results to determine the average amount of hemoglobin in one erythrocyte or red blood cell. Hemoglobin itself is a protein in erythrocytes which functions to deliver oxygen throughout the body. If the MCH results are below normal limits, this condition could indicate that the amount of hemoglobin in the red blood cells is low. This can be caused by several medical conditions, such as thalassemia or iron deficiency anemia. Meanwhile, MCH results that are above normal limits can be an indication of vitamin B12 and folic acid deficiency anemia.

Mean corpuscular hemoglobin concentration (MCHC) is a method of counting red blood cells which is carried out to determine the concentration or average level of hemoglobin in one

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erythrocyte. In adults, normal MCHC results range from 334–335 grams/liter. If the MCHC results are below normal limits, this condition could be an indication of iron deficiency anemia and thalassemia. Meanwhile, MCHC results that are above normal can be caused by injury or burns, hemolytic anemia, or hereditary spherocytosis.

Moderate and heavy alcohol consumption affects erythrocyte levels in the body. Mean red blood cell count, mean MCH, MCHC were normal among the non-alcoholic group and began to decline among moderate alcoholics and even more so among heavy alcoholics [8]. This decrease was also seen in platelet count and the difference was found to be most statistically significant.

Bidens pilosa has been reported to be used as herbal medicine to treat over 41 categories of disease in humans and animals [9]. Most of the functionality studies for *B pilos*a have been conducted in cells and rodent models [10-12]. More recently, one clinical pilot test showed that BP was therapeutically effective against diabetes in human patients [13]

It is important to maintain normal hematologic values in the body. Many factors cause disturbances in hematologic values, including iron deficiency, metabolic disease and also the effects of alcohol consumption. Handling of this hematological disorder can be done through daily foods such as vegetables *B pilosa* *B pilosa* (also known as black jack) is an erect perennial herb, 20–150 cm tall, globally distributed across temperate and tropical regions. It has been used traditionally in foods and medicines without obvious adverse effects and is an easy-to-grow and palatable perennial [14]. *B. pilosa* extracts also prevented the decline of superoxide dismutase (SOD) activity and the depletion of cytosolic glutathione (GSH) and ATP in erythrocytes. These results imply that *B. pilosa* may have protective antioxidant properties [15]. Several studies have been conducted on the efficacy of *B pilosa* and there is no data on the effect of B pilosa on hematologic values in rats that consume alcohol. The purpose of this study was to examine the effect of the ethanol extract of *Bidens pilosa* leaves (EEB) on the hematologic profile of white rats consuming alcohol

Materials and Methods

Animals and housing

Twenty-four outbred, adult male Wistar rats with a mean body weight of 180 - 250 g were used. The rats were housed one per cage in plastic cages (20x15x10 cm) containing wood chip bedding for enrichment purposes. The animals were maintained on standard pellet food (552 SP) and water ad libitum. They were housed in a environment on a reversed 12-h light/dark cycle with lights off at 7:00 A.M.

Processing and extraction of *Bidens pilosa*

Ketul plants (*Bidens pilosa* L) were obtained from Jonggol Jae village, Arse Tapanuli Selatan District, North Sumatra. 30 kg of fresh leaves are washed clean, then placed on parchment paper and dried in a closed room. Drying is done until the texture is crispy like crackers (± 10 days) then crushed using a blender until it forms a powder (simplicia). 1 kg of simplicia is put into a stainless steel pan then 96% ethanol was added in a ratio of 1:10 (1 kg of simplicia : 10 L of ethanol) and covered with aluminum foil. This soaking is done for five days and stirred every two days. After the maceration process, it is filtered using a coconut filter, then filtered again several times using Wattman filter paper until the ethanol juice of *B. Pilosa* leaves is obtained. The ethanol extract is

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concentrated using a rotary evaporator to remove or evaporate the ethanol, so that a concentrated pure extract is obtained. The final extract was kept at 4°C for further use.

Administration of alcohol

The alcohol used in this research is alcohol (C2H5OH) with a concentration of 30%. In research [16]. Administration of alcohol at a dose of 7.9 ml/kg body weight for 35 days resulted in liver tissue damage in experimental animals such as steatosis, degeneration, steatonecrosis and cirrhosis. Meanwhile, in research [17] giving 3 ml of alcohol for 15 days resulted in damage to liver tissue such as inflammation and necrosis. The alcohol dose in this study was 7.9 ml/kg of body weight. Alcohol was given every day for 42 days orally using a gastric tube.

Administration of *Bidens pilosa* Leaf Ethanol Extract (EEB)

EEB is given once a day for 42 days orally using a gastric probe. EEB dosage refers to research [16]. EEB was given orally to rat in the form of a solution with a concentration of 30%. The extract solution provided was dissolved with 0.5% CMC [18] (Patel et al., 2011). EEB is made by mixing 30 gr of EEB into 0.5% CMC solvent (0.5 gr of CMC in 100 ml of distilled water). So the EEB stock solution that has been mixed with 0.5% CMC is 30,000 mg/100 ml CMC or the same as 300 g/ml.

Parameters observation

On the 43rd day, all mice were anesthetized one by one in a chloroform tube, then the neck was dislocated, to obtain blood. Blood was collected in ependorf tubes coated with EDTA anticoagulant and analyzed for hematology. The parameters observed are as follows:

Red blood cells, hemoglobin, hematocrit, MCV, MCH, and MCHC

Determining or calculating the Erythrocyte Index Value is included in the Routine Hematology Examination (Complete Blood Count) in the examination itself using an automatic tool, namely a hematology analyzer. To get the MCV, MCH and MCHC values, first determine the parameters to be calculated, such as Hemoglobin, erythrocytes, hematocrit. So, here is how to calculate the MCV, MCH and MCHC values.

$$\text{MCV} = \frac{\text{Volume of packed cells/ 1000 ml of blood}}{\text{Red blood cell count in millions/ml}} \text{ fl or } \mu m^3$$

$$\text{MCH} = \frac{\text{Hemoglobin in g/ 1000 ml of blood}}{\text{RBC count in millions/ml}} \text{ pg/cell}$$

$$\text{MCHC} = \frac{\text{Hemoglobin in g/ 100 ml of blood} \times 100}{\text{Volume of packed cells/ 100 ml of blood}} \text{ g/dl or \%}$$

Platelet and platelet index

Platelets and platelet index are measured using an automatic tool, namely a hematology analyzer.

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Statistical Analysis

Data analysis with the one-way analysis of variance (ANOVA) was conducted with the Duncan's post hoc test. The results were presented as mean ± standard deviation (SD).

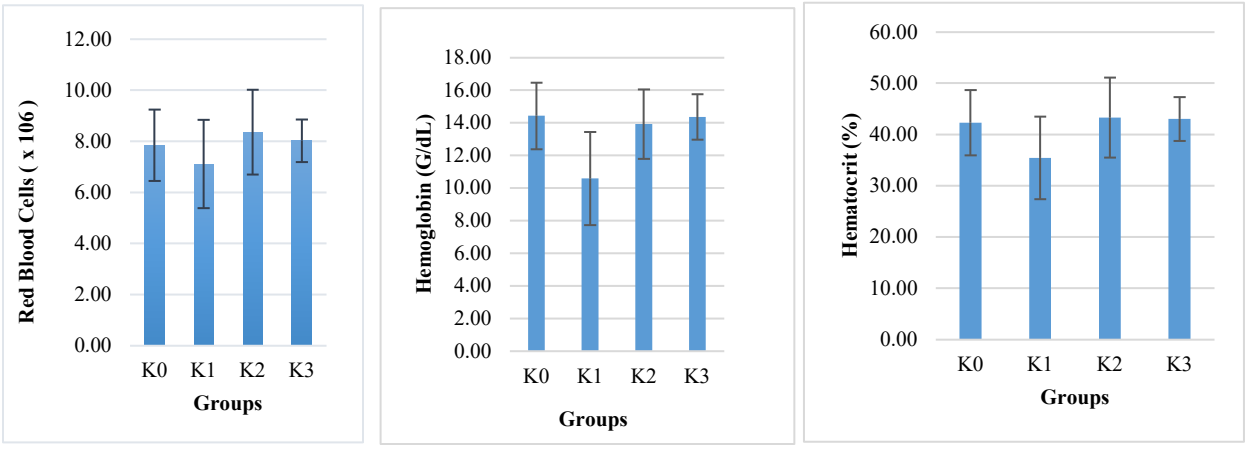
Result and Discussion

RBC, hemoglobin, hematocrit, MCV, MCH, and MCHC

Red Blood cells (RBC) in this study decreased significantly compared to group K1 (Figure 1a). Alcohol has a negative effect on the blood directly through toxic effects on bone marrow, blood cells and maturation of erythrocytes, leukocytes and platelets, while indirect effects through metabolic problems such as nutritional deficiencies. Both direct and indirect effects of alcohol will cause a decrease in the production of erythrocytes, leukocytes and platelets [19]. As a result of this, health problems will arise, including anemia. Giving EEB to both K2 and K3 increased RBC significantly compared to the K1 group. Quercetin is found in *B. pilosa*. Research results show that Polychlorinated biphenyls (PBCs) can cause blood damage and even blood cancer, and it is also reported quercetin prevented PCBs-induced alterations in the hematological and biochemical parameters [20]

Hemoglobin is a protein in RBC. RBC carry oxygen throughout the body. If you have a condition that affects your body's ability to make RBC, hemoglobin levels may drop. Low hemoglobin levels may be a symptom of several conditions, including different kinds of anemia and cancer. In Figure 1b, it can be seen that alcohol consumption reduces the amount of hemoglobin significantly ($p<0.05$) compared to controls, however, administration of EEB can increase hemoglobin again even higher than the hemoglobin level of control rat.

Normal hematocrit for rat aged 3-4 months is 40 – 50% [21]. In this study alcohol (K1) reduced hematocrit levels to below normal, namely 35,43 ± 8,06 %. Administration of EEB, namely in groups K2 and K3, increased hematocrit levels significantly ($p<0.05$) compared to K1 (Figure 1c). This decrease in HCT was reversed by treatment with EEB. This effect may be due to protective effect of EEB against alcohol-induced hemolysis.



a **b** **c**

Figure 1. The effect of *Bidens pilosa* on RBC (a) and Hemoglobin (b) and Hematocrit (c) of rats induce alcohol.

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Medicinal plants have been a source to control many diseases and anemia is no exception. In traditional systems of medicine including Ayurveda, many plants are claimed to be useful for anemia [22]. Previous studies reported antianemic potentials of several Indian medicinal plants [23]. Few poly-herbal formulations are reported to be effective for the treatment of anemia. Phytochemical analysis of the extract was also carried out. Administration of phenylhydrazine significantly decreased ($p < 0.05$) the levels of PCV, Hb, and RBC, respectively. Also, there is a significant increase in monocytes. Phytochemical analysis shows the presence of phenols, flavonoids, saponins, tannins, glycosides. Mucuna pruriens is effective in the treatment of PHZ induced hemolytic anemia [24]. These herbal based formulations are preferred by the community as they are cost-effective and have lesss ide effects. Increased RBC, Hb and Htc in this study indicating the plant extract may contain active agents which promote the action of erythropoietin (the humoral regulator of red blood cell production), and consequently increase production of erythrocytes [25]. Since the plants selected in the present study showed increase in haematological parameters of test animals indicating their boosting effects on the synthesis of haemoglobin and formation of red blood corpuscles due to their richness in iron and vitamin C hence these plants might have a promising role in the treatment and/or prevention of anaemia. Quercetin is found in *B. pilosa* [26]. Results of this study show that Polychlorinated biphenyls (PBCs) can cause blood damage and even blood cancer, and it is also reported that quercetin prevents PCBs-induced alterations in the hematological and biochemical parameters [20].

Red cell indices

Mean corpuscular hemoglobin (MCH) is one way to measure the healthof red blood cells. Abnormal MCH levels can help diagnose conditionslike anemia. The main condition MCH can help diagnose is anemia. Anemia is acondition that develops when body produces too few healthy redblood cells. Low levels of MCH can indicate iron-deficiency anemia while high levels of MCH can signal anemia caused by low levels of folic acid orvitamin B12. In this study, alcohol consumption significantly reduced MCH compared to the control group.

Table 1. Red Cell Indices

Group	MCV (fl)	MCH (pg/cell)	MCHC (g/dL)
K0	53.83 ± 2.11	18.08 ± 0.74	33.58 ± 0.84
K1	53.00 ± 1.54	17.64 ± 0.77	33.30 ± 0.93
K2	51.30 ± 2.41	17.05 ± 0.67	33.24 ± 0.81
K3	53.45 ± 1.87	17.85 ± 0.44	33.36 ± 0.65

Platelet (thrombocyte)

Thrombocytopenia (TP) is a reduction in platelet counts (PLT) below 150,000 in a microliter of blood. The reference range is 150,000–400,000/µL. A significant reduction in the number of platelets (less than 50,000/µL) may favor the occurrence of petechiae [12]. In this study, platelets decreased significantly ($p<0.05$) compared to the control group (Figure 2). The results of this study are in accordance with the results of research which states that platelets significantly ($p<0.001$) decrease in humans who consume both moderate and high alcohol consumption. [14]. Giving EDB

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in this study significantly increased the number of platelets compared to the control group and the group that consumed alcohol (K1).

Platelet index

Platelet indices are potentially useful markers of various diseases, yet their utility does not come without certain limitations. Preanalytical factors, such as, with- or without stasis vein puncture, anticoagulant used ethylenediamine tetraacetic acid-EDTA or citrate, temperature of blood sample or time between blood sampling and testing can influence the measurements of PIs [27]. Alcohol consumption significantly reduced Platelet levels (Figure 3), Plateletcrit, and PDW (Table 2) compared to control while MPV increased not significantly. Decreased Platelets, Plateletcrit and PDW are caused by several things caused by alcohol. The first is alcohol use can lead to either iron deficiency or excessively high levels of iron in the body. Because iron is essential to RBC functioning, iron deficiency, which is commonly caused by excessive blood loss, can result in anemia [21]. Because iron is essential to RBC functioning, iron deficiency, which is commonly caused by excessive blood loss, can result in anemia. In many alcoholic patients, blood loss and subsequent iron deficiency are caused by gastrointestinal bleeding.

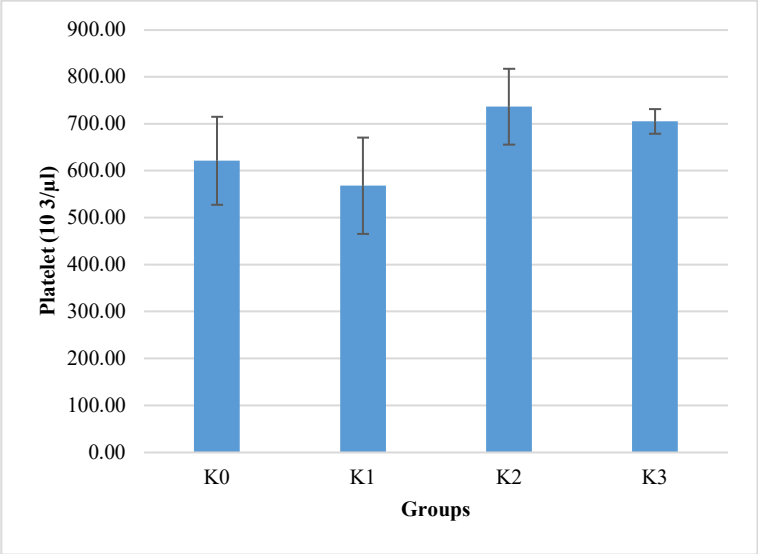

Figure 2. The effect of *Bidens pilosa* on Platelet of rats induce alcohol

Table 2. Index of Platelet

Group	RDW-CW	PDW	MPV	PCT
K0	14.62 ± 2.06	7.55 ± 0.44	7.75 ± 0.64	0.56 ± 0.19
K1	15.28 ± 1.89	7.68 ± 0.58	7.78 ± 0.46	0.36 ± 0.19
K2	15.58 ± 2.57	8.10 ± 0.83	7.83 ± 0.52	0.45 ± 0.21
K3	15.27 ± 2.10	7.28 ± 0.43	7.52 ± 0.57	0.51 ± 0.03

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Conclusion

Bidens pilosa ethanol extract significantly increased the number of red blood cells, Hemoglobin and Hematocrit in alcohol-treated rats. *Bidens pilosa* ethanol extract increased platelets, plateletcrit significantly in mice given alcohol.

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Development of tissue culture textbook based on scientific literacy in growth regulatory and production of metabolic secondary

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Abstract. *There are still very few textbooks with a tissue culture theme and based on scientific literacy on material on growth regulators and the production of secondary metabolite compounds found in the Medan State University library. Several available textbooks focus more on the content aspect than the process aspect. Therefore, this research aims to develop a tissue culture textbook based on scientific literacy regarding growth regulators and the production of secondary metabolite compounds so that it can be used as a learning resource for students in the Tissue Culture course. This type of research is Research & Development with the Dick & Carrey development model which is carried out up to the design and formative evaluation stages. The subjects of this research were Biology study program students class of 2018 who had taken tissue culture courses. The object of this research is the scientific literacy-based Network Culture textbook that was developed. Data collection through questionnaires, observation and documentation. The research instrument uses a questionnaire which is divided into two, namely a validation questionnaire by a team of experts (material experts, learning design experts, and layout design experts) and a response questionnaire from course lecturers and students. The results of the research show that the average score percentage for assessing tissue culture textbooks developed is according to material experts (98%), learning design experts (93%), layout design experts (93%), course lecturers (91%), and students. including individual trials (91%).*

Keywords: development, textbooks, network culture, scientific literacy

Introduction

Entering the 21st century, the education system is required to prepare students to be able to face competition in the global era [1]. In facing competition in the global era, students must have skills in scientific literacy [2]. Apart from that, students must have critical thinking skills, knowledge and abilities of digital literacy, media literacy, information literacy, mastering information and communication technology in facing learning in the 21st century [3]. However, the quality of Indonesian education, especially in terms of students' scientific literacy skills in the international arena, is still very low. The results of the PISA survey from 2000 to 2018 placed Indonesia as one of the countries with low scientific competence. Indonesian students' science competency data according to PISA in 2018 ranked 62nd out of 71 participating countries. In terms of the distribution of literacy itself, nationally only 25.38% of scientific literacy is considered sufficient, while 73.61% is considered insufficient. Most students in Indonesia are not yet able to analyze and apply concepts to solve a problem. Students are very good at memorizing, but are still less skilled in using the knowledge they have [4].

The low scientific literacy of students in Indonesia is caused by many factors, one of which is that the learning demands that apply so far in Indonesia are different from the demands of PISA [5]. According to the opinion of science education experts [6], learning patterns in schools (including in universities) so far still emphasize mastery of content rather than through scientific processes, causing students to have low scientific literacy. In improving the scientific literacy abilities of Indonesian students, it is necessary to improve the scientific literacy abilities of prospective educators so that students will achieve high performance. Apart from that, teachers need to be skilled and professional in implementing sufficient learning time, optimizing space, and having lots of reference learning resources [7].

Biology students' scientific literacy abilities are still relatively low. This can be seen from the large number of students who still have difficulty understanding the lecture material and have difficulty analyzing the lecture material given. Based on research results Novitasari [8], the lowest percentage score was found in the indicator of understanding and interpreting basic statistics with

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a score of 43.1% and the average score for biology students' scientific literacy abilities for all indicators was 58.21%. Network culture is one of the subjects that students consider difficult. Based on the distribution of questionnaires to Unimed Biology students, it was found that 79% of students stated that the tissue culture course on growth regulators and the production of secondary metabolite compounds was difficult material. The results of research [9] stated that the level of learning difficulty for Unimed students from the cognitive aspect in the material on growth regulators was 67.69% and on the material on secondary metabolite compounds it was 62.45%. Apart from that, the learning indicator aspect of the level of student learning difficulties in the analysis of the role of growth regulators was 69.09% and on the benefits of secondary metabolites was 62.40%. The main factor causing difficulties for Unimed biology students in learning tissue culture courses is that existing Tissue Culture textbooks emphasize the content dimension rather than the process dimension [10].

Observation results in accessing tissue culture books based on scientific literacy, especially material on growth regulators and the production of secondary metabolite compounds, are still difficult to find in libraries and their availability via the internet is still very minimal even though this textbook will really help students to improve their scientific literacy skills. students need to face competition in the global era. Science literacy-based textbooks can improve students' scientific literacy skills and learning outcomes [11], [12]. The advantage of textbooks that are facilitated with scientific literacy is that they contain categories of scientific literacy including science as a body of knowledge, science as an investigative nature, science as a way of thinking, and the interaction of science, technology, and society so that the book developed does not only emphasize the content dimension, but also contains context, process and attitude dimensions that can help and direct students to learn independently, have the ability to think scientifically and critically and use scientific knowledge to develop decision-making skills [13] . Based on this, it is necessary to develop a tissue culture textbook based on scientific literacy regarding growth regulators and the production of secondary metabolite compounds according to the assessment of material experts, learning design experts, layout design experts, course lecturers and students.

Research Methods

The development of the Network Culture textbook refers to the Dick & Carrey model which consists of: (1) needs analysis and goal identification; (2) instructional/learning analysis; (3) learner and context analysis; (4) formulate performance goals; (5) developing assessment instruments; (6) developing learning strategies; (7) developing and selecting learning materials; (8) designing and conducting formative evaluations; (9) make revisions; (10) designing and conducting summative evaluations. The limitation of this research is only the design and formative evaluation stage.

Data collection was carried out through questionnaires, observation and documentation. The questionnaire was used to obtain data regarding the condition or suitability of the Network Culture textbook which was developed according to expert validators, and to find out the response of the Network Culture course lecturers and students. Observations are needed to see what the initial condition of the Network Culture book is before development is carried out in order to determine the needs needed in the field.

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Data analysis

The data obtained was then analyzed based on the Likert scale that had been scored [14] (Table 1).

Table 1. Guidance criteria for determining Likert scale type scoring

No	Answer	Score
1	Very good	4
2	Good	3
3	Not good	2
4	Not good	1

The feasibility level is calculated using the formula [14]:

$$P = \frac{\Sigma}{N} x100\%$$

Information:

P : Category presentation
Σ : The total score of the selected category answers
N : Totalideal score

Determination of validation criteria is determined in the following way [14]:

a. Determine the lowest score, namely: lowest weight x number of indicators
b. Determining the highest score is: highest weight x number of indicators
c. Determine the scale range, namely:

$$Scale\ range = \frac{\mathrm{m(n-1)}}{n}$$

Information:

m :Number of indicators
n :Number of alternative answers

The score classification is then converted into a percentage and then interpreted qualitatively in sentences. The material expert's assessment criteria for the suitability of a tissue culture textbook based on scientific literacy regarding material on growth regulators and secondary metabolite production can be seen in Table 2.

Table 2. Material expert assessment criteria for the suitability of tissue culture textbooks

Total score	Percentage interval	Criteria	Qualification
146 – 179	82 % ≤x ≤ 100%	Very worthy	Teaching material products are ready to be used in the actual field for learning activities/not revision.
112 – 145	63 % ≤x ≤ 81%	Worthy	Teaching material products can be used in the field for learning activities but there are slight revisions.
78 -– 111	44% ≤x ≤ 62%	Not worth it	Revise teaching materials by reviewing them carefully and looking for product weaknesses to improve.
44 – 77	25 % ≤x ≤ 43%	Very inadequate	Product fails, major and fundamental revision of product content.

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Learning design experts' assessment criteria for the suitability of a tissue culture textbook based on scientific literacy for material on growth regulators and secondary metabolite production are shown in Table 3.

Table 3. Instructional design experts' assessment criteria for the suitability of tissue culture textbooks

Total score	Percentage interval	Criteria	Qualification
103 – 126	82 % ≤x ≤ 100%	Very worthy	Teaching material products are ready to be used in the actual field for learning activities/not revision.
79– 102	63 % ≤x ≤ 81%	Worthy	Teaching material products can be used in the field for learning activities but there are slight revisions.
55 – 78	44 % ≤x ≤ 62%	Not worth it	Revise teaching materials by reviewing them carefully and looking for product weaknesses perfected.
31– 54	25 % ≤x ≤ 43%	Very inadequate	Product fails, major and fundamental revision of product content.

The layout design expert's assessment criteria for the suitability of a tissue culture textbook based on scientific literacy for material on growth regulators and secondary metabolite production can be seen in Table 4.

Table 4. Layout design experts' assessment criteria for the suitability of tissue culture textbooks

Total score	Percentage interval	Criteria	Qualification
60 – 73	82 % ≤x ≤ 100%	Very worthy	Teaching material products are ready to be used in the actual field for learning activities/not revision.
46 – 59	63 % ≤x ≤ 81%	Worthy	Teaching material products can be used in the field for learning activities but there are slight revisions.
32 – 45	44 % ≤x ≤ 62%	Not worth it	Revise teaching materials by reviewing them carefully and looking for product weaknesses to improve.
18 – 31	25 % ≤x ≤ 43%	Very inadequate	Product fails, major and fundamental revision of product content.

Layout design experts' assessment criteria for the suitability of a tissue culture textbook based on scientific literacy for material on growth regulators and secondary metabolite production are shown in Table 5.

The layout design expert's assessment criteria for the suitability of a tissue culture textbook based on scientific literacy for material on growth regulators and secondary metabolite production can be seen in Table 6.

Results and Discussion

Needs and goals analysis

Based on the results of the analysis, it was found that 79% of students had difficulty understanding the material on growth regulators and the production of secondary metabolite compounds.

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Students need textbooks that can provide complete information regarding the use and role of growth regulators in tissue culture, methods/processes for the production of secondary metabolite compounds, including techniques for increasing the production of secondary metabolite compounds, because the available textbooks do not present this information completely. Apart from that, students also think that the Network Culture textbook is good, but because in this course there are no practicums but all activities are related to laboratory activities, students need to add/present applicable examples in the textbook related to the material presented. The textbooks used also have shortcomings in the presentation of images, the images presented are not clear and have no color. The language used is difficult for students to understand because there are many terms or Latin, but explanations are not provided, and exercises are not provided that help students evaluate their understanding. Therefore, the solution that can be provided and is the aim of this research is to develop a tissue culture textbook according to student needs.

Table 5. Criteria for assessing course lecturers regarding the suitability of tissue culture textbooks

Total score	Percentage interval	Criteria	Qualification
146 – 179	82 % ≤x ≤ 100%	Very worthy	Teaching material products are ready to be used in the actual field for learning activities/not revision.
112 – 145	63 % ≤x ≤ 81%	Worthy	Teaching material products can be used in the field for learning activities but there are slight revisions.
78 – 111	44 % ≤x ≤ 62%	Not worth it	Revise teaching materials by reviewing them carefully and looking for product weaknesses to improve.
44 – 77	25 % ≤x ≤ 43%	Very inadequate	Product fails, major and fundamental revision of product content.

Table 6. Criteria for student assessment of the suitability of tissue culture textbooks

Total score	Percentage interval	Criteria	Qualification
69 – 84	82 % ≤x ≤ 100%	Very worthy	Teaching material products are ready to be used in the actual field for learning activities/not revision.
53 – 68	63 % ≤x ≤ 81%	Worthy	Teaching material products can be used in the field for learning activities but there are slight revisions.
37 – 52	44 % ≤x ≤ 62%	Not worth it	Revise teaching materials by reviewing them carefully and looking for product weaknesses to improve.
21 – 36	25 % ≤x ≤ 43%	Very inadequate	Product fails, major and fundamental revision of product content.

The results of the needs and objectives analysis revealed that 79% of students had difficulty studying the material on growth regulators and the production of secondary metabolite compounds. The results of research [15] state that Tissue Culture is considered difficult for students to understand, because to understand Tissue Culture material requires a basic understanding of several other branches of science such as plant physiology, plant morphology, plant anatomy, genetics, laboratory techniques and other branches of science.

Students also have difficulty understanding the methods/steps that need to be taken in Network Culture, have difficulty finding problems in the surrounding environment that are related to Network Culture and have difficulty solving problems related to Network Culture. Apart from

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that, students also do not understand the advantages and disadvantages of Network Culture. This is in accordance with research [16] that students have difficulty identifying and explaining the process and steps in carrying out tissue culture and students also do not understand the advantages and disadvantages of carrying out tissue culture.

Learning analytics

Based on the results of observations, it is known that the network culture learning activities carried out require students to learn independently, be able to present the material they will study and the assignments given require students to be able to carry out mini-research or carry out investigations related to the material being studied. However, the existing textbooks do not support or are in line with learning activities and the demands of the assignments given, because the information in the existing textbooks is incomplete and does not provide applicable examples or information regarding how to carry out investigations related to the material presented so that students have difficulty learning independently. Apart from that, students also have difficulty finding tissue culture books in the Unimed library, The online books that students can access are also not much different from existing network culture textbooks, which emphasize the content dimension rather than the process dimension, and there are no network culture textbooks based on scientific literacy, even though scientific literacy-based textbooks do not only focus on dimensions. content but also processes, contexts and attitudes that will really help students learn independently and improve their scientific literacy skills so they are able to face competition in the global era. In fact, information on material for the production of secondary metabolite compounds is very rarely found in online books, so students have limited information. even though scientific literacy-based textbooks do not only focus on content dimensions but also process, context and attitudes which will really help students learn independently and improve their scientific literacy skills so they are able to face competition in the global era. In fact, information on material for the production of secondary metabolite compounds is very rarely found in online books, so students have limited information. even though scientific literacy-based textbooks do not only focus on content dimensions but also process, context and attitudes which will really help students learn independently and improve their scientific literacy skills so they are able to face competition in the global era. In fact, information on material for the production of secondary metabolite compounds is very rarely found in online books, so students have limited information.

Based on the results of the learning analysis, it is known that learning activities have led to scientific literacy activities and supported students to have scientific literacy skills, but this is not in line with or supported by existing textbooks. The textbooks used by students focus more on the content dimension than the process dimension. The results of research [17] state that the Network Culture textbooks currently used by Unimed students emphasize the content dimension rather than the process dimension so that students have difficulty studying this subject. Apart from that, the Network Culture book is also difficult to find in the Unimed library. None of the network culture books circulating so far, including those that can be accessed online, are based on scientific literacy.

Learner and context analysis

Based on statements from students from the 2018 Unimed Biology study program, it is known that out of 39 students, 59% of students liked the material on regulatory substances and the production of secondary metabolite compounds. Another 41% of students considered the material on growth regulators and the production of secondary metabolite compounds as not interesting material to

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study. Based on the results of observations made on 39 students of the 2018 Unimed Biology study program during the learning activities, it was discovered that all students were ready to take part in the learning activities and listened to the lecturer when explaining. However, only 6 students actively asked questions and looked enthusiastic about participating in learning activities. The use of textbooks in learning activities is not optimal, and most students stated that they rarely used it and focused more on the learning media provided by lecturers or students who presented and presented power points. The use of textbooks is rarely used because the demands of the assignments and directions conveyed by existing textbooks are not in line. Apart from that, there are competencies that are difficult to develop in students, namely competencies related to case studies in Network Culture, data analysis in Network Culture and competencies related to Network Culture applications. This is shown by students who cannot answer questions from lecturers regarding case studies in network culture, benefits tissue culture and the difficulty of drawing conclusions from the data that has been presented. The use of textbooks is rarely used because the demands of the assignments and directions conveyed by existing textbooks are not in line. Apart from that, there are competencies that are difficult to develop in students, namely competencies related to case studies in Network Culture, data analysis in Network Culture and competencies related to Network Culture applications. This is shown by students who cannot answer questions from lecturers regarding case studies in network culture, benefits tissue culture and the difficulty of drawing conclusions from the data that has been presented. The use of textbooks is rarely used because the demands of the assignments and directions conveyed by existing textbooks are not in line. Apart from that, there are competencies that are difficult to develop in students, namely competencies related to case studies in Network Culture, data analysis in Network Culture and competencies related to Network Culture applications. This is shown by students who cannot answer questions from lecturers regarding case studies in network culture, benefits tissue culture and the difficulty of drawing conclusions from the data that has been presented.

Based on the results of the learner and context analysis, it is known that of the 39 students, only 6 students were active and enthusiastic about participating in learning activities. Students also have difficulty mastering competencies related to case studies in Network Culture, data analysis in Network Culture, and competencies related to Network Culture applications. Existing textbooks are rarely used by students and are more focused on PPTs presented by lecturers or classmates in presentations, because the demands of the assignments and directions conveyed by existing textbooks are not in line. This shows that existing textbooks do not meet student needs. So students and lecturers need textbooks that can be used as a reference in learning activities in accordance with the learning outcomes of the course and their needs so that learning activities are more focused, effective and efficient. The results of research [18] state that using textbooks that suit students' needs will provide opportunities and guidance for students to be able to understand all competencies thoroughly and systematically and help lecturers in their teaching activities so that learning activities can run smoothly.

Formulate Performance Goals

Performance's aim in developing a tissue culture textbook based on scientific literacy on material on growth regulators and the production of secondary metabolite compounds is to help students majoring in Biology at Unimed improve their scientific literacy skills. Through the use of the textbooks being developed, it is hoped that it can help students learn independently, be scientifically literate and be able to think critically and be ready to face competition in the global era. Therefore, the formulation of learning outcomes is formulated in accordance with the learning

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outcomes that have been determined in the RPS for the Tissue Culture course in the Unimed Biology department as follows:

Teaching materials on growth regulators

1. Students are able to differentiate the physiological effects of each growth regulator
2. Students are able to identify the role of growth regulators in tissue culture
3. Students understand the use of growth regulators in tissue culture
4. Students are able to find and solve problems in the surrounding environment related to growth regulators.

Teaching materials for production of secondary metabolite compounds

1. Students can describe the factors that influence the production of secondary metabolite compounds.
2. Students are able to identify the benefits of producing secondary metabolite compounds through tissue culture.
3. Students can conclude the role of tissue culture in the production of secondary metabolite compounds.
4. Students are able to produce secondary metabolite compounds through tissue culture.
5. Students are able to find and solve problems in the surrounding environment related to the production of secondary metabolite compounds.

Tissue Culture is one of the courses in the Unimed Biology department which is included in science learning. Science learning is one way to increase scientific literacy. To increase scientific literacy through science learning, appropriate textbooks or books oriented towards scientific literacy are needed so that learning activities can run well. However, there is no Tissue Culture textbook on growth regulators and the production of secondary metabolite compounds based on scientific literacy, therefore it is necessary to develop a Tissue Culture textbook on growth regulators and the production of secondary metabolite compounds based on scientific literacy [19]. This is in accordance with the opinion of [20] that textbooks function as a link to learning resources and greatly determine the educational success of students in demanding learning. Therefore, textbooks used in learning activities must be facilitated with scientific literacy so as to help students improve their scientific literacy. The results of research [21] state that improving literacy learning outcomes for students cannot be separated from the use of teaching materials and learning patterns that are oriented towards scientific literacy.

Developing assessment instruments (assessments)

The instrument developed was a questionnaire. This questionnaire is used by expert validators as a guide to assess or as a reference for the validity or suitability of the textbook being developed, and a response questionnaire by lecturers in the Network Culture course and students. There are five types of questionnaires developed, namely:

1. Assessment/validation sheet by material experts consisting of 44 question points consisting of aspects of material suitability with course learning outcomes, material accuracy and scientific literacy.
2. Assessment/validation sheet by a learning design expert consisting of 31 question points consisting of aspects of appropriateness of presentation, appropriateness of language, and scientific literacy.
3. Assessment/validation sheet by a layout design expert consisting of 18 question points

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consisting of aspects of graphic feasibility including cover design, book content design, typography, and illustrations/images.

4. The lecturer's response questionnaire sheet for the Network Culture course consists of 44 question points consisting of aspects of book appearance, material presentation, and scientific literacy with four answer choices available, namely: (4) very good, (3) good, (2) poor good, (1) not good.
5. Student response questionnaire sheet consisting of 21 question points consisting of aspects of image presentation, book design, attractive appearance, clarity of writing, language, material content, student motivation, and information acquisition.

Developing learning strategies

The learning strategy used to present the Network Culture textbook which was developed to be based on scientific literacy is to apply inquiry-based science learning activities. Inquiry learning is learning that places students as scientists in order to understand nature as an application of science and provide explanations for what they observe. Inquiry learning can also help lecturers link the material they teach with real world situations and encourage students to make connections between the knowledge they have and its application in everyday life. Thus, this inquiry learning can increase students' scientific literacy and learning becomes more meaningful for students. Based on these, Inquiry-based learning strategies are applied in making textbooks which are contained in four components of scientific literacy according to [22] including: (1) science as a body of knowledge; (2) science as a way of investigating; (3) science as a way of thinking; and (4) interaction of science, technology and society.

Based on this, the learning strategy applied in the Network Culture book so that it is oriented/based on scientific literacy is to implement inquiry-based science learning activities which refer to the four components of scientific literacy according to [22] including: 1) science as the body of knowledge (a body of knowledge); (2) science as a way of investigating; (3) science as a way of thinking; and (4) interaction of science, technology and society. This is in accordance with the opinion of [23] that inquiry learning is learning that is able to make students become scientists who attempt to understand nature as an application of science and provide explanations for what they observe. Inquiry learning can also help teachers link the material they teach with real world situations and encourage students to make connections between the knowledge they have and its application in everyday life. Thus, this inquiry learning can increase students' scientific literacy and learning becomes more meaningful for students.

Developing and selecting learning materials

At this stage, the development and selection of learning materials that are suitable for use in the preparation of books is carried out, which consists of two design stages, namely:

Material preparation

The material presented and developed in the scientific literacy-based Tissue Culture textbook is growth regulators and the production of secondary metabolite compounds which are arranged in accordance with the learning outcomes of the course (CP-MK). In compiling the material in the book, there are two main sources used, namely the Plant Tissue Culture book used by Unimed Biology students written by [24]. Furthermore, the material content in the book is compiled from various sources such as books, scientific journals, and proceedings with the aim of enriching the information in the textbook being developed. The composition of the content and materials in the

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scientific literacy-based network culture textbook can be seen in Table 7.

Table 7. Composition of content and material in the tissue culture textbook

Subject	Sub Topics
Cover	
Foreword	
List of contents	
List of tables	
list of figures	
Introduction	
Chapter I. Growth substance regulator	
Concept maps	
Learning outcomes	
Introduction	
Science as a body of knowledge (a body of knowledge)	a. Definition of growth regulators b. Types of growth regulators: auxins, cytokinins, gibberellins, ethylene, abscisic acid, retardants, other groups of ZPTs, and non-existent ZPTs general.
Summary	
Science as a way to investigate (way of investigating)	Come on investigate influence concentration substance growth regulator on onion regeneration white (*Allium sativum* L.) by tissue culture
Science as a way of thinking	a. Let's think scientifically b. About matchmaking c. About right and wrong d. Multiple choice questions
Interaction of science, technology with public (interaction of science, technology and society)	a. Fruit ripening cambium and b. Herbicide c. Stimulation activity xylem development
Chapter II. Production of Secondary metabolite compounds	
Concept maps	
Learning outcomes	
Introduction	
Science as a body of knowledge (a body of knowledge)	a. Secondary metabolites in plants b. Types and structure of secondary metabolites c. Development of production of secondary metabolite compounds d. General procedure for the production of metabolic compounds

The development of the Network Culture textbook consists of two stages, namely material

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selection and format selection. The selection of material in textbooks is adjusted to the learning outcomes of the course, the materials prepared are obtained from various library sources, such as textbooks, scientific articles or journals and mass media [25]. The information obtained is then packaged and adapted to student needs, then organized and written as a textbook using a systematic framework. The textbooks developed are prepared by paying attention to the principles of relevance, consistency and adequacy in selecting the learning materials used. The results of research [26] state that the principles that need to be considered in preparing teaching materials or learning materials include the principles of relevance, consistency and adequacy.

Format selection

The textbook presentation format that was developed was created or compiled with the help of Microsoft Word on A4 paper size (21cm x 29.7 cm) with font using Times New Roman font with a font size of 12 pts for all contents except chapter titles 48 pts, sub-chapters 14 pt, image captions and tables 10 pt. Spacing 1.5 except for image and table captions spacing 1.15. The typing margin size for each page is 4-3-3-3 cm (left-top-bottom-right) with multi pages: mirror margins. The front cover of the book contains the title of the book at the top slightly to the middle, below the title of the book there is an image that supports the title of the book, and at the bottom of the front cover of the book there is the author's name. The back cover of the book displays sentences that describe the contents of the book, the book title and the author's name.

Choosing a format for textbooks includes several things such as paper size, margins, typeface, font size, spacing and cover. Aspects that need to be considered in choosing a format, namely typography (type of letters, spacing, width and form of arrangement), layout (pattern or margin, balance and suitability), illustrations (attractiveness of the image), cover (front cover and back cover) and book size [27].

Designing and conducting formative evaluations

Designing and carrying out formative evaluation is the evaluation stage carried out by developers during the development of the Network Culture textbook. After going through the previous stages, the initial product was obtained for a scientific literacy-based Network Culture textbook, then at this stage an evaluation was carried out to obtain a scientific literacy-based Network Culture textbook that was valid/appropriate. The initial product produced was validated by expert validators including material experts, learning media design experts, layout design experts, and asked for responses from Network Culture course lecturers and students. The assessment results are in the form of a score which is then converted into percent units and then adjusted to the product eligibility criteria. The results of validation by expert validators are used to revise the product being developed according to the suggestions and criticism given until it is valid or reaches a good feasibility figure. Furthermore, the products developed were asked for responses by students. The scientific literacy-based Network Culture textbook that was developed was assessed from the aspects of material, learning design, layout design and scientific literacy components. These criteria have been included on the validation sheet which is assessed by the validator. A product produced can be said to be of good quality if it meets valid and practical criteria.

The scientific literacy-based Network Culture textbook that was developed was assessed by expert validators including material experts, learning design and layout design. After going through a revision process based on comments and suggestions from material expert validators, learning design and layout design, an average score was obtained from each expert, namely; 98%, 93% and 93%. The average assessment is included in the "very feasible" criteria and the product

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is declared valid so that the revision of the textbook from the expert validator has been completed. As argued by [30] that revisions to the development product are complete if the validator has stated that the product is valid. This assessment shows that the teaching material products are ready to be used in the actual field for learning activities.

The results of research on the development of tissue culture textbooks based on scientific literacy regarding growth regulators and secondary metabolite production based on material experts, learning design experts, layout design experts, course lecturers and students are shown in Table 8 to Table 12.

Validation results by material experts

Material validation was carried out by material expert Mr. Prof. Dr. Ir. A. Rafiqi Tantawi, MS. as a lecturer in the UMA and Unimed Postgraduate Tissue Culture courses. Material expert assessment is carried out to revise the content of the material in the book being developed so that a suitable textbook is obtained.

Table 8. Percentage of assessment by material experts

Component	Indicator	Before Revision		After Revision	
		Score(%)	Criteria	Score(%)	Criteria
Eligibility of content					
Suitability of material to course learning outcomes	Material coverage	92	Very worthy	100	Very worthy
	Depth of material	94	Very worthy	100	Very worthy
Material accuracy	concept accuracy, facts, data and definitions	100	Very worthy	100	Very worthy
	Example accuracy	92	Very worthy	92	Very worthy
	Image accuracy and illustrations	83	Very worthy	100	Very worthy
	Accuracy of terms	100	Very worthy	100	Very worthy
	Symbol accuracy	100	Very worthy	100	Very worthy
	Reference accuracy References	100	Very worthy	100	Very worthy
	Up-to-date material	92	Very worthy	92	Very worthy
Components of scientific literacy					
Scientific literacy	Science as a stem body	100	Very worthy	100	Very worthy
	Science as a way to investigate	100	Very worthy	100	Very worthy
	Science as a way to think	97	Very worthy	97	Very worthy
	The interaction of science, technology, and public	100	Very worthy	100	Very worthy
Average		96	Very worthy	98	Very worthy

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Validation results by learning design experts

Learning design validation was carried out by learning design expert Mr. Prof. Dr. rer. Nat. Binari Manurung, M.Sc. as a Biology lecturer at Unimed. The learning design expert assessment was carried out to revise the learning design of the book being developed to make it better.

Based on Table 9, the average assessment from learning design experts before the revision was 87% with very feasible criteria and after the revision was 93% with very feasible criteria. The assessment results show that in terms of learning design, according to learning design experts, the textbooks developed are very suitable for use. The average assessment result from learning design experts before revision was 87% with very feasible criteria. Things that need to be revised according to learning design experts include the formulation of learning outcomes, suitability of the placement of questions with scientific literacy components, mention of pictures and tables in the text content, writing a bibliography.

Learning design experts stated that the textbooks that were developed were very feasible in terms of learning design because the textbooks that were developed were in accordance with the indicators contained in the learning design instrument, such as the appropriateness of presenting the material, the effect on learning, language, and the suitability of the placement of the material with the components of scientific literacy. has been fulfilled. The form of arrangement in compiling textbooks must pay attention to the structure and systematic presentation of material, language, and provide convenience and effect for students in understanding the material presented in textbooks [28].

Table 9. Percentage of assessment by learning design experts

Component	Indicator	Before Revision Score (%)	After Revision Criteria	Before Revision Score (%)	After Revision Criteria
Appropriat enesspresen tation	Presentation of material	83	Very worthy	92	Very worthy
	Effects on learning	81	Worthy	88	Very worthy
Linguistic feasibility	Language	81	Worthy	88	Very worthy
Scientific literacy	Science as a stem body	100	Very worthy	100	Very worthy
	Science as a way to investigate	100	Very worthy	100	Very worthy
	Science as a way to think	81	Worthy	88	Very worthy
	Interactionscien ce, technology, and public	81	Worthy	94	Very worth y
	Average	87	Very worthy	93	Very worthy

Validation results by layout design experts

Learning design validation was carried out by learning design expert Mr. Dr. Gamal Kartono, M.Sc. as a fine arts lecturer at Unimed. Learning design expert assessments are carried out to

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improve the quality of book layout designs to make them more attractive.

Based on Table 10, the average assessment from layout design experts before the revision was 85% with feasible criteria and after revision was 93% with very feasible criteria. The assessment results show that in terms of layout design, according to design experts, the textbook layout developed is very suitable for use. The average assessment results from layout design experts for the feasibility of textbook layout designs before revision was 85% with very feasible criteria. According to layout design experts, things that need to be revised in textbooks are the front and back covers, font size and spacing for image and table captions, cover design and images in both chapters, unclear images, and font color and background color in images. .

Layout design experts stated that the textbooks that were developed were very feasible in terms of learning design because the textbooks that were developed were in accordance with the indicators contained in the layout design instrument such as graphic appropriateness (pattern consistency, color contrast, size and type of letters, writing layout and images, and proportional images), textbook content design, typography, and harmonious and creative illustrations/images have been fulfilled. Color management is something that requires special attention in presenting textbooks [31]. The presentation of book contents must pay attention to clarity, simplicity and systematicity including the use of font size and type, layout of writing and images [32].

Validation results by course lecturers

After carrying out revisions and the Tissue Culture textbook product being developed is declared valid, the product will then be given to the Plant Tissue Culture lecturer to obtain feedback from the Plant Tissue Culture course lecturer to improve the book being developed before handing it over to students. The results of the responses of lecturers in the Network Culture course to the Network Culture textbook that was developed can be seen in Table 11.

Based on Table 11, the results of the responses from lecturers in the Network Culture course, the textbook developed has an average score of 91% with very appropriate criteria. As a result of the responses from lecturers in the Network Culture course, the textbook developed had an average score of 91% with very appropriate criteria.

Table 10. Percentage of assessment by layout design experts

Component	Indicator	Before Revision		After Revision	
		Score (%)	Criteria	Score (%)	Criteria
Graphic feasibility					
Cover design	Consistency pattern	75	Worthy	100	Very worthy
	Has corners good view	75	Worthy	75	Worthy
	Has contrast good color	75	Worthy	100	Very worthy
	Easy font size and type be read	100	Very worthy	100	Very worthy
	Writing layout and harmonious image	100	Very worthy	100	Very worthy

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	The picture has proportional shape	75	Worthy	100	Very worthy
Book content design teach	Layout	88	Very worthy	94	Very worthy
Typography	Easy font size and type be read	100	Very worthy	100	Very worthy
	The use of spaces makes text easy be read	100	Very worthy	100	Very worthy
Illustrations/drawingstextbooks	Illustrations/drawings has a proportional shape	75	Worthy	75	Worthy
	Presentation the whole illustration is harmonious	83	Very worthy	92	Very worthy
	Creative illustration	75	Worthy	75	Worthy
Average		85	Very worthy	93	Very worthy

The lecturer in the Network Culture course stated that the textbook being developed was very feasible because the textbook being developed was in accordance with the indicators contained in the course lecturer's response assessment instrument, such as the appearance of the textbook, presentation of the material, and scientific literacy. So the textbook developed is very suitable to be used as a learning resource in Network Culture learning. This is based on research conducted by [33] showing that the best learning resources in the world cannot fulfill their function if the learning resource is not liked by a teacher. Meanwhile, according to the assessment results from lecturers in the Network Culture course, the textbook that has been developed has appropriate and can be used in learning.

Table 11. Percentage of assessment by course lecturers

Component	Indicator	Before Revision		After Revision	
		Score (%)	Criteria	Score (%)	Criteria
Graphic feasibility					
Cover design	Consistency pattern	75	Worthy	100	Very worthy
	Has corners good view	75	Worthy	75	Worthy
	Has contrast good color	75	Worthy	100	Very worthy
	Easy font size and type be read	100	Very worthy	100	Very worthy
	Writing layout and harmonious	100	Very worthy	100	Very worthy

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	image				
	The picture has proportional shape	75	Worthy	100	Very worthy
Book content design teach	Layout	88	Very worthy	94	Very worthy
Typography	Easy font size and type be read	100	Very worthy	100	Very worthy
	The use of spaces makes text easy be read	100	Very worthy	100	Very worthy
Illustrations/drawingstextbooks	Illustrations/drawings has a proportional shape	75	Worthy	75	Worthy
	Presentation the whole illustration is harmonious	83	Very worthy	92	Very worthy
	Creative illustration	75	Worthy	75	Worthy
Average		85	Very worthy	93	Very worthy

The scientific literacy component in the textbooks being developed cannot be separated from the assessment of material expert validators, learning design experts and network culture lecturers. The scientific literacy component in the Network Culture textbook is considered to have been fulfilled because the textbook developed not only contains aspects of content but also aspects of context, attitudes and scientific processes. The textbook that has been developed contains the four components of scientific literacy according to the opinion of [22] including: 1) science as the body of knowledge; (2) science as a way to investigate; (3) science as a way of thinking; and (4) interaction of science and technology with society. Characteristics of the contents of books based on scientific literacy are: 1) the scientific information in the textbook is in accordance with developments in science and things that have just been discovered in the world of science; 2) building a framework by displaying pictures to provide curiosity, which includes tests and summaries between concepts to make it easier for students to appreciate each concept; 3) students can learn more enthusiastically by giving quizzes that involve students being able to think logically and examining the ability to grasp the meaning of students' basic ideas based on question sentences found in science as a way of thinking; 4) looking for relationships between materials through scientific research, science, technology and society through explanations about the process of aspects of science that are carried out and the position of science in life [34].

Validation results by students

Taking student responses is carried out after the textbook developed is declared valid/appropriate by expert validators and lecturers in the Network Culture course.

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Table 12. Percentage of assessment by students

Indicator	Individual Response		Small Group Response		Limited Group Response	
	Score (%)	Criteria	Score (%)	Criteria	Score (%)	Criteria
Picture which served	92	Very worthy	93	Very worthy	93	Very worthy
Book design teach	88	Very worthy	89	Very worthy	91	Very worthy
Attractiveness appearance	89	Very worthy	90	Very worthy	92	Very worthy
Clarity writing	92	Very worthy	92	Very worthy	93	Very worthy
Language	90	Very worthy	91	Very worthy	91	Very worthy
Contents of the material	89	Very worthy	89	Very worthy	90	Very worthy
Motivating student	92	Very worthy	91	Very worthy	91	Very worthy
Acquisition information	92	Very worthy	93	Very worthy	93	Very worthy
Average	91	Very worthy	91	Very worthy	92	Very worthy

This assessment was divided into three groups, namely individual responses or trials for three students, small group trials for eight students, and group trials for twenty students. The results can be seen in Table 12.

Based on Table 4.9, the percentage of student responses regarding the Network Culture textbook which was developed to support Network Culture lectures and increase students' scientific literacy, both from individual trials, small group tests and limited group trials, the average score of student assessments/responses is 91%. 91%, 92% are classified as very feasible criteria. These results show that the textbook used is very suitable for students to use in studying tissue culture, material on growth regulators and the production of secondary metabolite compounds.

After obtaining responses from the course lecturers, testing was then carried out on Unimed biology students who were divided into three groups, namely: one-on-one/individual trials, small group trials, and large group trials to obtain information on responses or assessments of the textbooks. developed. One-on-one/individual trials are carried out to obtain initial input regarding the product or design being developed, small group trials are carried out to determine the feasibility and response of students to products developed on a small scale, and large group trials are carried out to determine the feasibility and response of students towards products developed on a larger scale than previous trials [35].

The results of responses from students majoring in Biology, Medan State University regarding the Tissue Culture textbook which was developed to support Tissue Culture lectures and increase

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students' scientific literacy both from individual trials, small group tests and limited group trials. The average score of student assessments/responses is 91 %, 91%, and 92% with very feasible criteria. The textbooks developed were declared very suitable by students because the textbooks developed were in accordance with the indicators contained in the student response assessment instrument such as attractiveness of appearance, display design, images presented, clarity of writing, language, material content, motivation, and obtaining information from the book that was developed so that it can be used by students in studying tissue culture, material on growth regulators and the production of secondary metabolite compounds. This is based on the opinion that the response of students as users of textbooks is important to express because students are users of textbooks, the textbooks that will be used must be tested and in accordance with the needs and character of textbook users [36].

Conclusion

The results show that the average percentage score for development of tissue culture textbooks based on scientific literacy in growth regulation and production of metabolic secondary is classified as very feasible based on materials experts (98%), learning design experts (93%), layout design experts (93%), course lecturers (91%) and students (92%). This shows that this textbook is very suitable to be used as a learning resource.

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Mangrove sediment carbon stock on the east coast of North Sumatra

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Abstract. *Global warming occurs due to increased emissions of greenhouse gases, one of the most influential gases is carbon dioxide. Absorption of carbon dioxide in the soil, especially in mangrove ecosystem soils, can contribute more than other ecosystems to reducing the impact of global warming. The purpose of this study is to determine the amount of carbon stock in mangrove sediments at different depths in 5 areas on the East Sea Coast of North Sumatra and determine which area has the greatest potential for carbon storage. Sampling was carried out using the Purposive Sampling method by directly determining the point where the sample was taken. Sample handling was carried out using the loss on ignition method by collecting data on soil sample depth, sample intervals and soil density (density) which were analyzed and obtained the percentage of organic carbon stock in the soil. The results showed that the highest soil density was at Jorni Beach at a depth of 60-100 cm of 1.64 gcm^{-3} ± 0.232, the highest carbon content value of organic sediment material was at the Sicanang station at a depth of 60-100 cm with a value of 25.95 gcm^{-3} ± 5.575. The largest total carbon storage at the Silo Laut Beach station is 1129.85 Mg C ha^{-1}.*

Keywords: carbon stock, east coast of North Sumatra, loss on ignition, mangrove sediment, purposive sampling

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Introduction

Climate change is one of the environmental problems that is currently developing. This happens because there is global warming that caused by increased greenhouse gas emissions. One of the most influential greenhouse gas emissions to global warming is carbon dioxide (CO_2). The increase the carbon dioxide in the atmosphere comes from human activities, such as the burning of fossil fuels in the form of oil and coal, industrial activities and exhaust gases from motor vehicles [1]. These human activities are not easy to control because of the demand for a better life. On the other hand, mitigation and adaptation efforts to reduce the impact of CO_2 gas as a greenhouse effect have not fully gone well.

The mangrove ecosystem has a role as an absorber of CO_2 from the air during the photosynthesis process. Mangrove forests store more carbon than most tropical rainforests. Most of the absorbed carbon is stored in the soil and is rich in carbon-rich sedimentary material several meters deep underground [2]. Absorbed of CO2 in soil or organic carbon can contribute to reducing the impact of climate change. In addition, measuring the amount of mangrove sediment in a field can describe how much carbon stock is increasing in the soil and protecting carbon-rich soil is very important to achieve a balanced climate target.

Mangrove forests in Indonesia according to [3] have carbon storage of around more than 4 gigatonnes C/year to 112 gigatonnes C/year. However, not all residents are aware of the importance of the function of mangrove forests in their area. Based on research [4] from the North Sumatra Elephant Foundation, it shows that there was a decline in mangrove forests in North Sumatra in 1989 covering an area of 96,000 Ha, in 2002 it became 63,000 Ha, in 2009 it shrank to 26,000 Ha, and experienced a slight increase in growth in 2014 to 36,000 Ha. Data from the North Sumatra Environmental Agency (BLH) in 2013 showed that 90% of North Sumatra's mangrove forests were in badly damaged condition, the reason being the conversion of land to oil palm plantations which reached 12,000 Ha, and the conversion to ponds reaching 10,000 Ha.

Logging and burning of mangrove forests can cause dry out of mangrove sediments and increase microbial activity after the loss of the anaerobic environment. This can cause oxidation of the soil and cause the release of carbon into the atmosphere [5] whereas soil sediments can store more carbon than biomass and are rich in organic matter [6].

Mangrove forests play an important role as climate change mitigation by storing carbon [7,8]. Mangrove forests also have great potential to become new markets for carbon trading [5]. In East Kalimantan, an effort has been made to manage mangroves to achieve the emission reduction target and receive compensation payments from the World Bank in 2024 [9] .

The global average atmospheric carbon dioxide level in 2020 was 412.5 ppm, a record high despite the economic slowdown due to the COVID-19 pandemic. The 2.6 ppm increase above the 2019 level was the fifth highest annual increase in NOAA's 63-year record. Since 2000, the amount of global atmospheric carbon dioxide has increased by 43.5 ppm or 12% In Indonesia [10], CO2 emissions come from coal of 99,718 kg CO_2 / TJ with an average value of carbon content of 27.2 kg C / GJ, and an NCV of 19.8 TJ / Gg [11]. BPS data for 2019 Greenhouse Gas Emissions by Sector Type in 2017 covering the energy, Industrial Processes and Product Use (IPPU), Agriculture, Waste, Forestry and other Land Uses (FOLU) sectors, and Forest Fires totaling 1,150,772 (thousand tons of CO_2e) [12].

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Collective data on carbon stocks from the mangrove forests of North Sumatra have not been available to date. Recent research in North Sumatra on mangrove species diversity and carbon stocks in silvofishery ponds in Deli Serdang Regency [4]. Data like this is needed to determine the contribution of climate change mitigation in Indonesia from each province. Therefore this research is considered very important to be used as a baseline data source for climate change mitigation data in North Sumatra.

Recognizing the existence of these problems, it is necessary to analyze carbon stocks in mangrove forests so that they can be used in efforts to reduce climate change. Therefore, accurate quantification of carbon stocks and specific locations is very important for estimating future carbon stocks as a result of mangrove forest conservation and assisting communities in utilizing mangrove forests so that economic sustainability is maintained.

Materials and Methods

Study area

The research was conducted from July to November 2022. Sampling of mangrove sediments was carried out at 5 stations representing 4 regencies on the East Coast of North Sumatra, namely Jorni Beach and Tapak Kuda Lama (Langkat Regency), Sicanang (Medan City), Sei Naga Lawan (Serdang Bedagai District), and Silo Laut Beach (Asahan District). The detailed research site can be seen in figure 1. Furthermore, sample analysis was carried out at the Physics Laboratory of Medan State University.

Figure 1. Map of carbon stock sampling location in east coast of North Sumatera, Indonesia. Red circle is sampling stations of mangrove sediments.

Sampling method

For sampling in the field, tools and materials are needed, namely sediment, corer, plastic sample box, GPS (Coordinate Map Application), tape measure, camera, stationery and label paper. Furthermore, for sample analysis in the laboratory, tools and materials are needed, namely

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analytical scales, digital scales, sample cups, mortar, oven, porcelain crucible, and muffle furnace.

Sediment samples were obtained from 5 areas in the East Sea Coastal Region of North Sumatra. The procedure used in sampling is *in situ sampling* directly in the field [13]. Sampling to determine carbon stocks in mangrove ecosystems is focused on soil organic matter or sediments in mangrove ecosystems which is carried out using *the purpose sampling method* or directly determining the sampling location points. At each sampling station, 5 (five) points were determined in the mangrove area each at a depth of 0-30 cm, 30-60 cm and 60-100 cm which represent the front, middle and rear of the perpendicular or along the coast depending on mangrove conditions. Each depth was repeated 3 (three) times until the total number of samples at each station was 15 samples. The total sample from 5 stations is 75 samples.

The sampling technique at 5 different stations. Sampling at Jorni Beach was carried out parallel to the coast, because the mangrove layer is very thin with the mangrove distance from coast to land less than 50 m. Sampling at the Tapak Kuda Lama mud flat was carried out in the middle of a bed of mud and was carried out by drawing a straight line 500 m long. Sampling in Sicanang was carried out along the river flow, collection was carried out at 2-3 m from the river bank, the distance between one point to the next point was 100-200 m. In the Sei Naga Lawan area, sampling was carried out following the river channel which was perpendicular to the coast at a distance of 100 m. In the Silo Laut Beach area, sampling was carried out along the pedestrian path in the middle of the mangrove forest.

The thing that was done when collecting samples was cleaning organic waste and fresh leaves from the soil surface. Then, drilling the soil vertically at a predetermined point until the depth reaches the mark on the drill 0-30, 30-60, and 60-100 cm. Next, the drill is withdrawn to retrieve the sediment intact. The samples that have been obtained are split horizontally, and divided based on 3 depths (3 samples), namely 0-30 cm, 30-60 cm and 60-100 cm. The samples obtained were then put into sample plastic bags and labeled on each bag to facilitate identification and analysis in the laboratory. The sample is stored in the refrigerator so that it can last until it is time to be analyzed in the laboratory [14].

After sampling at the location is completed, the samples obtained are analyzed in the laboratory using *the loss on ignition* (LOI) method [15]. The thing to do is to place the sediment samples obtained in the prepared cup. Then it was put into the oven to dry for 48 hours and the temperature was set at 60^{o}C. After drying, the sediment samples were then crushed using a mortar so that the conditions of each sample became homogeneous. Next, place each sample that is mashed back into the sample plastic bag. The next step, take and weigh 3 grams of sediment samples and place them in a porcelain crucible. Then burned in the Muffle furnace with a temperature of 450^{o}C for 4 hours. Next, the sample is weighed again and the results are recorded.

Data analysis

The data analyzed consisted of soil density, percentage of sediment organic matter lost in the combustion process, carbon content of organic sediment material, carbon density, and total carbon content.

The formula used to calculate soil density/Bulk Density (BD) is presented in the equation:

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$$BD = \frac{\text{oven-dry mass}}{\text{sample volume}}$$

Where; Soil density (BD) is the content of the mud substrate (gram/cm3), Oven-dry mass is the mass of the dried sample (grams) and sample volume (cm3) is the volume of the sample obtained from the results of measuring the height of the sample with the diameter of the *corer*.

Dry ashing is calculated using the equation:

% BO = ((Wo-Wt)/Wo x 100)

Where; % BO is the percentage of sediment organic matter lost in the combustion process; Wo is dry weight before burning (grams); Wt is the final weight after burning (grams)

The conversion of the percentage of organic matter into the percentage of carbon is calculated using the equation:

% C = (0,580) x % BO

Where; % C is the carbon content of organic sedimentary material; % BO is the percentage of sediment organic matter (ashing); 0.580 is the constant for converting % organic matter to % organic C.

The carbon density content in soil is calculated by the equation:

Soil C density (g C cm^{-3}) = % C x BD (Soil Density)

Where; Soil C density (g C cm-3) is the density of carbon; %C is the carbon content of organic sedimentary material; BD is the density of the soil (g/cm3) .

Total Carbon Content is calculated by the equation:

Soil C (MgC ha^{-1}) = BD x SDI (Soil Depth Interval) x % C

Where; Soil C (MgC ha-1) is an estimate of carbon storage; BD is the density of the soil (g/cm3); SDI is the sample depth interval (cm) [14].

Results and Discussion

Soil density

Soil density or commonly called Bulk Density (BD) shows the weight of the dried soil mass per unit volume. Soil density has spatial (space) and temporal (time) variability, caused by variations in organic matter content, soil texture, soil structure, types of fauna, and soil depth [16]. From the results of the analysis, it is known that the soil at each depth at the 5 stations has a different

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density value. The average value of soil density at each station in the location can be seen in Figure 2.

From Figure 2, it can be seen that the highest soil density at Jorni Beach at a depth of 60-100 m is 1.64 g/cm3 ± 0.232[a], while the lowest value at a depth of 30-60 m is 0.9 g/cm3 ± 0.49[b] at the Jorni Beach location. This is because the condition of the mangrove sediments in the Jorni Beach area has a sandy loam texture. Based on (Ayu et al. 2020) it is known that the soil density value in mangrove ecosystems is affected by soil texture which is closely related to particle composition. The relatively high soil density is caused by the predominance of sand particles and low clay particles which causes the soil to become massive. This is also supported by research (Permatasari et al. 2019), soil substrates which are dominated by sand have a small surface area making it more difficult to hold water and nutrients.

In addition to these factors, the depth of mangrove sediments also affects the soil density value. According to [2] states that the increasing depth of the mangrove forest, the soil density value also increases. The soil density value will affect the organic matter content of the soil in relation to its effect on the rate of decomposition of organic matter and ultimately affect the amount of carbon stored in the soil.

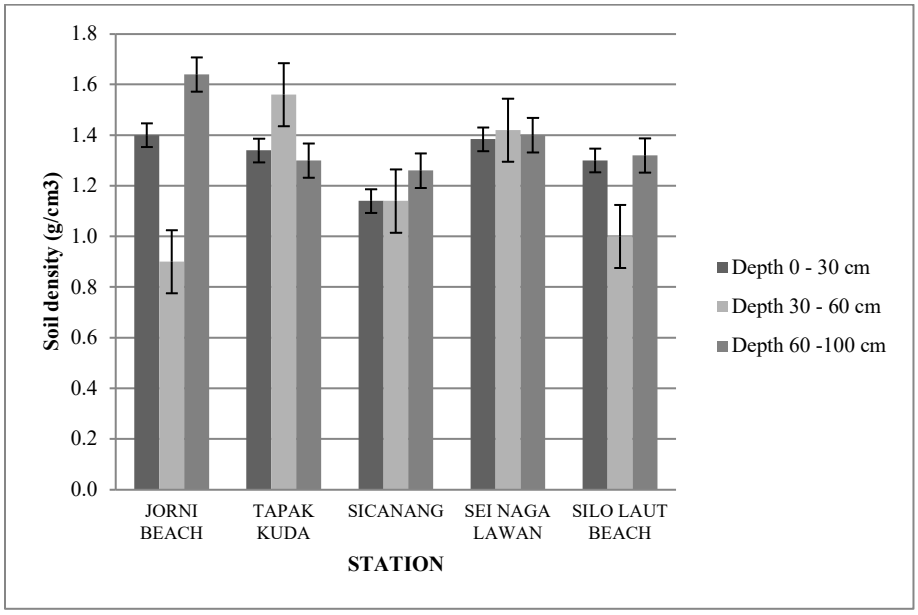

Figure 2. Comparison of Soil Density at five station in three depths

Carbon content of organic sediment materials

From the results of the analysis, the value of the carbon content of organic sedimentary material was obtained from each station and different values were obtained (Figure 3). From the results of the analysis it is known that the highest value of carbon content of organic sediment material is at Sicanang station at a depth of 60-100 m with a value of 25.95 % ± 5.575[b] while the lowest value is found at Tapak Kuda Lama station with a depth of 0-30 m of 3.867 % ± 2.1506[b]. The high content of organic carbon in sediments in the soil is due to the fact that sediments receive a lot of carbon contributions in the form of dead leaves, twigs, fruit and flowers (litter).

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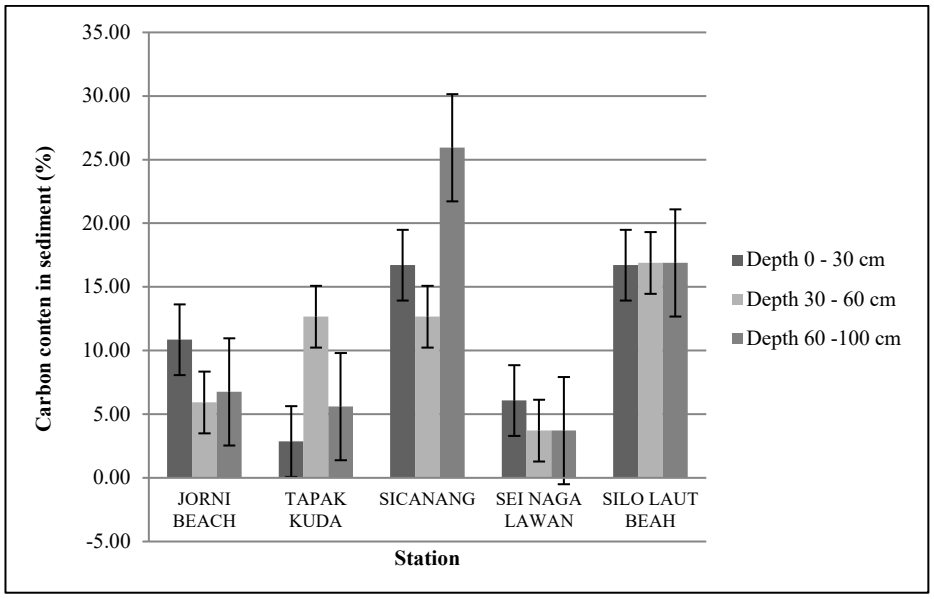

Figure 3. Comparison of carbon content in organic sediment materials

Carbon density (g C cm^{-3})

Carbon density shows the density of carbon in mangrove organic sediments.

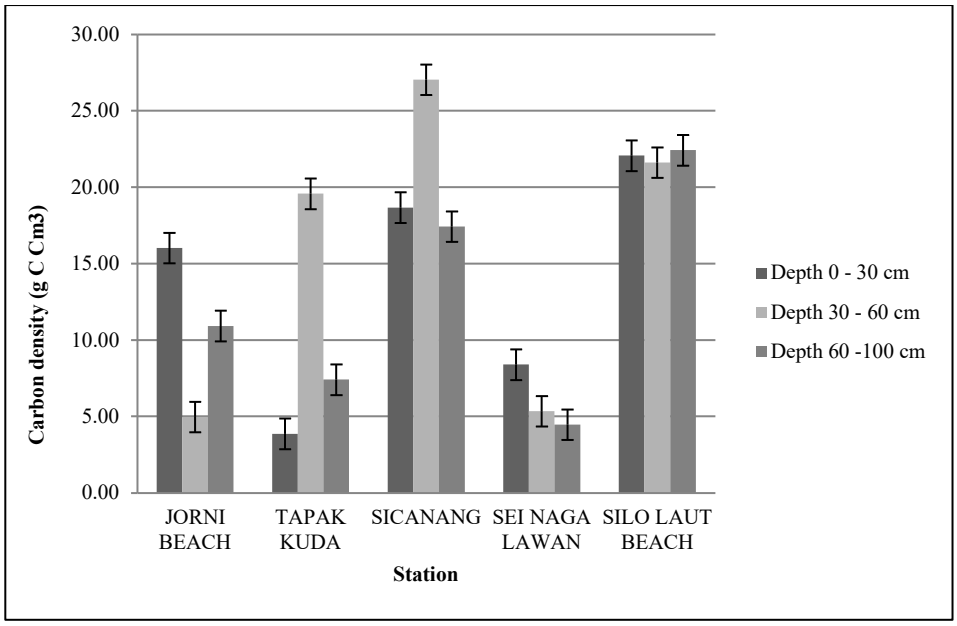

Figure 4. Comparison of carbon density

From the results of the analysis, soil carbon density values were obtained from each station and different values were obtained (Figure 4). From the analysis results, it is known that the highest sediment carbon density value is at a depth of 30-60 m at the Sicanang station with a

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value of 27.04 g C cm-3 ± 7.418[c] while the lowest value is found at Tapak Kuda Lama station with a depth of 0-30 m of 3.867 g C cm -3 ± 2.1506[b].

Carbon storage (Mg C ha^{-1})

Carbon storage in soil is the accumulated weight of carbon stored in the soil in a certain area. The level of soil carbon storage is determined from three interrelated variables, namely the concentration of organic carbon, soil specific gravity, and soil depth [16].

The results of measuring carbon storage at five stations have different results of carbon storage. The value of carbon storage is measured vertically with three different depths. The depths measured are 0 – 30 cm, 30 – 60 cm, and 60 – 100 cm. Where each depth has a different carbon storage value. The highest carbon storage at a depth of 0-30 cm was found at Silo Laut Beach station of 385.5 Mg C ha^{-1} ± 164.73 and the lowest value at Tapak Kuda Lama station of 42.8 Mg C ha^{-1} ± 26.05[a]. The highest carbon storage at a depth of 30 – 60 cm was found at the Sicanang station at 420.4 5 Mg C ha^{-1} ± 114.99[b] and the lowest at the Sei Naga Lawan station at 48.5 5 Mg C ha^{-1} ± 37.48[b]. The highest carbon storage at a depth of 60 – 100 cm was found at the Silo Laut Beach station at 359.8 5 Mg C ha^{-1} ± 202.58[a] and the lowest at the Sei Naga Lawan station at 38.8 5 Mg C ha^{-1} ± 32.25[b]. Different values are affected by soil fertility, plant density and diversity, and how they are managed [17]. This is because the data collection conditions at each station are different.

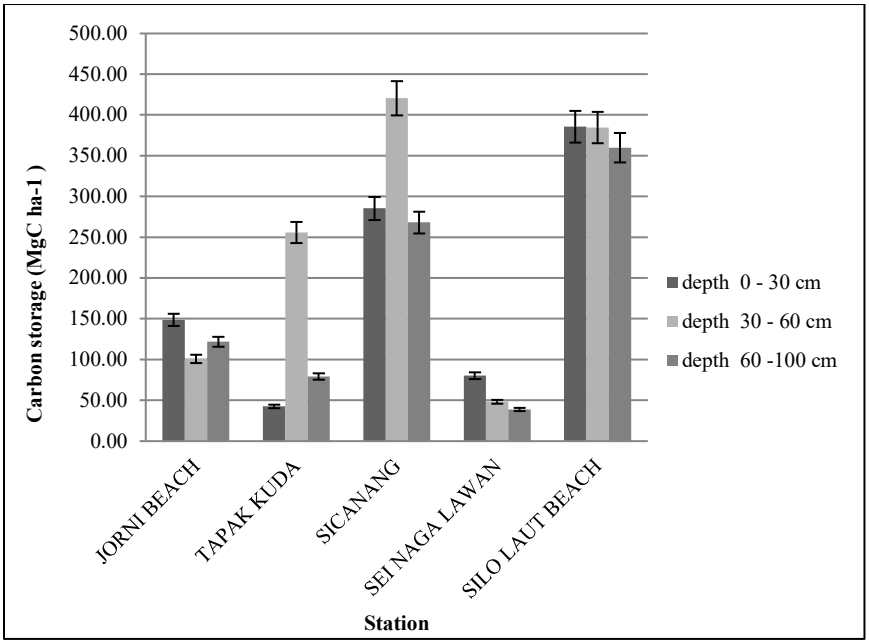

Figure 5. Comparison of estimation of carbon stores

The total carbon storage at the Jorni Beach station is 371.3 5 Mg C ha^{-1}. At the Tapak Kuda Lama station, the total carbon storage is 378 5 Mg C ha^{-1}. At the Sicanang station, the total carbon storage is 973.8 5 Mg C ha^{-1}. At the Sei Naga Lawan station, the total carbon storage was 167.6 5 Mg C ha^{-1}, while the total storage at Pantai Silo Laut station was the largest of the four

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other stations, namely 1129.8 5 Mg C ha^{-1}. The difference in the amount of carbon stock at the five stations is due to the density level of mangroves which varies from high to low. In addition, the proximity factor of the station to the estuary also has an effect so that it has high nutrients as well. The source of carbon stocks in the soil comes from the weathering of litter that falls and is buried in the ground [18].

Table 1. Total carbon content (Mg C ha^{-1}) by station and depth

Sampling Station	Depth			Total
	0 – 30 cm	30 – 60 cm	60 - 100 cm	
Jorni Beach	148.6 ± 68.12[a]	100.8 ± 33.84[b]	121.9 ± 30.76[ab]	371.3
Tapak Kuda Lama	42.8 ± 26.05[a]	255.9 ± 72.14[b]	79.3 ± 35.33[c]	378
Sicanang	285.3 ± 145.79[a]	420.4±114.99[b]	268.1 ± 68.78[a]	773.8
Sei Naga Lawan	80.3 ± 25.33[a]	48.5 ± 37.48[b]	38.8 ± 32.25[b]	167.8
Silo Laut Beach	385.5 ± 164.73[a]	384.5±168.82[a]	359.8 ± 202.58[a]	1129.8

Carbon storage is one of the most important environmental services provided by mangrove forests. Data show that total carbon storage in mangrove forests is very high when compared to most upland forest types, and little has been done to measure the amount of carbon stored [13]. The potential carbon stock in each component, both biomass and soil organic matter, will affect the total carbon stock. The higher the mangrove biomass, the higher its ability to absorb CO2 gas [19]. Based on field conditions when sampling, the condition of each mangrove ecosystem can be described from 5 stations. The Jorni Beach Station has the highest total carbon content at a depth of 0 – 30 cm. Initially the condition of the mangrove ecosystem at this station was quite good, but due to deforestation, the longer the carbon content it contains, the lower it is. Along with reforestation, the tendency for carbon content to increase again.

At the Tapak Kuda Lama station, it is known that the land used as a place for fishermen to live shows a small carbon content, this is because there is very little mangrove vegetation at this station because a lot of it has been converted into residential areas. However, after the land was abandoned by residents due to rising sea levels, the tendency for carbon content to increase was very high. At a depth of 0 -30 cm the trend in the future will have a high carbon content along with the absence of human disturbance at that location.

At the Sicanang station, it is known that the preservation of the mangrove ecosystem has been good from the start, so the carbon content is also very high. As time goes by, the carbon content tends to be higher and has a chance at a depth of 0 – 30 cm and in the future it will have a very high carbon content.

At the Sei Naga Lawan station, it was known that the initial conditions for this sampling location were that the mangroves were very critical so that the carbon content was very small, but as the mangrove replanting activities increased, the results of carbon storage increased. In line with research [4], it is known that the condition of the Sei Naga Lawan mangrove forest suffered the heaviest damage in 1996 due to land conversion into ponds which damaged around 300 m^2 of mangrove forest being converted into shrimp ponds.

At the Silo Laut Beach station, it was known from the start that mangrove forests were already well characterized by high carbon content per ha at a depth of 60 – 100 cm. Along with the improvement and increase in reforestation land, it shows an increase in carbon content. At a

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depth of 30 – 60 cm the carbon content increases and is followed by an increase in carbon content at a depth of 0 -30 cm.

With the existence of collective data on carbon stocks and the condition of the mangrove forests of the East Coast of North Sumatra, it plays a role in knowing the contribution of climate change mitigation in Indonesia from each region. In addition, information on the total amount of carbon stocks can be put to good use for the benefit of carbon trading which is expected to increase the economic level of the community around the mangrove ecosystem area and make people aware that the mangrove ecosystem in the area around where they live has a lot of potential.

Conclusion

The results showed that the highest soil density was at Jorni Beach at a depth of 60-100 cm of 1.64 gcm^{-3} ± 0.232, the highest carbon content value of organic sediment material was at the Sicanang station at a depth of 60-100 cm with a value of 25.95 gcm^{-3} ± 5.575. The largest total carbon storage at the Silo Laut Beach station is 1129.85 Mg C ha^{-1}.

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Saurauia vulcani korth against hepato-renal carcinoma integrated spleen damage in rats induce rhodamine b : in vivo and in silico

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Abstract. *Spleen as the largest immune organ could be associated in the treatment of hepato-renal carcinoma exposure to xenobiotic compounds, for instance Rhodamine B. The therapeutic effects of Saurauia vulcani extract (EEP) were investigated in rats administered RhB via histopathological measurement and molecular docking. 24 adult male rats (weighed 150-200 g) were divided into 4 groups (n=6) consist of (a) Group P1 : Control group; (b) Group P2 received orally rhodamine B 980 mg/kg for 30 days; (c) Group P3 was given EEP at dose 500 mg/kg for 30 days; (d) Group P4 received orally rhodamine B 980 mg/kg and EEP 500 mg/kg. Our data showed that EEP at dose of 500 mg/kg BW (P4 groups) could significantly ($p \leq 0.05$) improve the histological of spleen and decrease the diameter of white pulp spleen 90.607 ± 13.627 compared to RhB treated groups at 114.662 ±20.923. Furthermore, molecular docking study revealed the evaluated compound of EEP has the best binding affinities against spleen tyrosine kinase, MTOR of hepatocellular carcinoma, and Gap Junctional intercellular communication (Cx43) of renal cell carcinoma. Moreover, this study could be the potential candidate as a targeted anti- hepato-renal carcinoma with further validations.*

Keywords: *Saurauia vulcani, Hepato-renal carcinoma, Spleen Tyrosine Kinase, Histopathological measurement, Molecular docking*

Introduction

Hepato-renal carcinoma is a complication in patients with the chronic diseases caused by severe oxidative damage by toxic chemicals [1], for instance Rhodamine B. The correlative evidence between spleen as an immune defense indicator and the progression of hepato-renal carcinoma is reported in the previous studies [2,3]. In addition, spleen tyrosine kinase is a cytoplasmic non-receptor protein tyrosine kinase in the regulation of signal transduction expressed in kupffer cells which is associated with the severity of liver [4]. Moreover, Gap

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junctions, for instance connexin43 (Cx43), contributed to the progression of tumors in hepato-renal carcinoma [5].

Furthermore, the natural products for the treatment purposes have been investigated to significantly suppress the metastatic and reduce mitotic activity in the development of hepato-renal carcinoma [6,7]. *Saurauia vulcani* is known as Pirdot and has been used as a medicine for relieving some ailments, such as wound healing, anti-diabetic, anti-cholesterol and anti-bacterial [8,9,10,11]. Besides, the previous study has reported the phytochemical contents of Pirdot containing ursolic acid, oleanolic acid, corosolic acid, maslinic acid, beta sitosterol and genistein [12]. The bioactivities of EEP have exhibited immunostimulant effect, hepatoprotective, and antioxidative [13,14,15,16].

However, the potential of Pirdot against hepato-renal carcinoma integrated spleen damage in Rhodamine induced rats has not been investigated. Therefore, this research is purposed to evaluate the protective effect of EEP through histopathological measurement and molecular docking study.

Materials and Methods

Preparation of S. vulcani extract and Experimental Data

The dried leaves of *S. vulcani* were powdered and macerated in 96% alcohol at room temperature 27^0 C. The result was filtered by Whatman paper, suspended with 96% alcohol, soaked for two days, and filtered. The solution was evaporated by rotary evaporator and kept at 4^0 C for further analysis [17]. Twenty-four Rats (weighing 150- 200 gr) were taken from the laboratory of Karya Inovasi Cendikia. All experimental animals were divided into four groups (n =6) consist of : (a) The first group (P1) as control group received distilled water and standard laboratory diet; (b) The group P2 were administered orally Rhodamine B at dose 980 mg/kg BW for 30 days; (c) The group P3 were given EEP at dose 500 mg/kg BW for 30 days; (d) The group P4 received Rhodamine at dose 980 mg/kg BW and EEP at dose 500 mg/kg BW.

Histopathological measurement

At the end of the experimental period (30 days), all the treated animals were anesthetized. The spleens were collected, and cleaned. The portions of spleen were immediately fixed into 10% formalin for two days. After that, the tissues were embedded into paraffin, cut into 3-5 µm using a rotary microtome and stained with haematoxylin and eosin (H&E) [18].

Molecular docking

The 3D structure of the selected active compound of Pirdot was obtained form the PubChem database (**https://www.ncbi.nlm.nih.gov/pccompound/**). The protein target such as Spleen Tyrosine kinase (PDB: 3EMG) [19], MTOR (PDB: 4JT6) [20] and Cx43 (Gap Junctional intercellular communication of renal cell carcinoma) (PDB: 7XQB) [21] were downloaded from the PDB database (**https://www.rcsb.org/**). Water and original ligand of the active center was removed by using PyMOL software. The protein target and the selected active compounds were formatted in '.pdbqt' file. The molecular docking study was performed by AutoDock Vina. The binding pose with the lowest score was visualized as the docking conformation by BOVIA Discovery software.

Data Analysis

The experimental data were expressed as mean ± SD. Statistical analysis was evaluated by using one-way analysis of variance (ANOVA) followed by Duncan's multiple Range Test (DMRT). Differences between groups were considered significant at p – value ≤

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0.05.

Results and Discussion

Spleen Weight and Diameter of white pulp spleen

The experimental data showed that the spleen weight ratio was 1.6983±0.36745 at the control group, while the RhB (P2) significantly ($p \leq 0.05$) decreased the spleen weight ratio at 1.4617±1.7589. However, EEP at a dose of 500 mg/kg BW significantly improved the size of the spleen at 1.7017±3.0492 in rats induced RhB groups, as depicted in Table 1**.** Besides, Our finding demonstrated that the size of white pulp was 95.318±16.574 at the control group, however the administration of RhB ($p \leq 0.05$) at dose 980 mg/kg significantly increased the size of white pulp at 114.662±20.923. The size of white pulp spleen returned to normal when treated with EEP at 90.607±13.627 as shown in Table 1.

Table 1. Mean Spleen weight ratio and white pulp spleen of the treatment study on the induced Rhodamine B in rats.

Treatment	Spleen weight ratio (g)±SD	Diameter of white pulp spleen (µm) ± SD
Group 1 (P1)	1.6983±0.36745	95.318±16.574
Group 2 (P2)	1.4617±1.7589	114.662±20.923
Group 3 (P3)	1.8240±7.6015	73.676±8.7309
Group 4 (P4)	1.7017±3.0492	90.607±13.627

Histopathology assay

The histopathological measurement revealed that the control groups of white spleen showed normal histoarchitecture which are arranged with lymphocytes and no congestion in the red pulp of the spleen. In contrast, Rhodamine B exposure at a dose of 980 mg/kg for 30 days resulted in massive damage such as discrete lymphocyte architecture, irregular shape and necrotic debris in white pulp spleen. However, the administration of EEP at dose 500 mg/kg BW improved the spleen histopathological alteration as shown in Fig. 1.

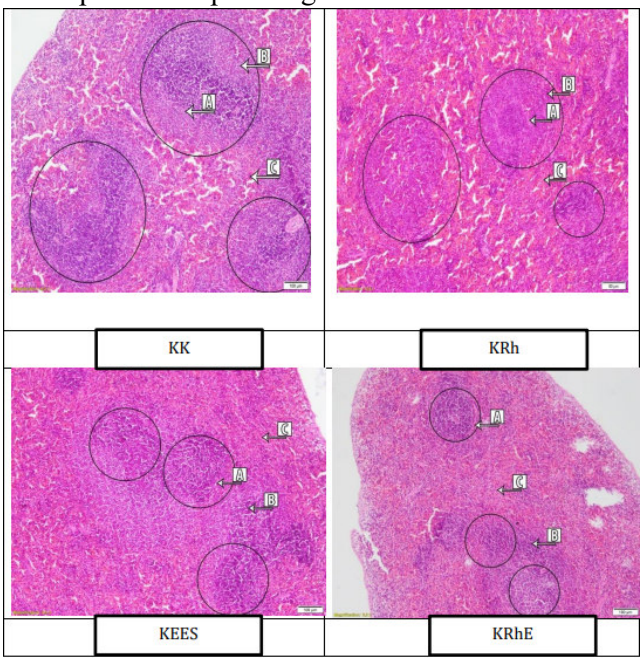

Figure 1. Photomicrograph (H&E stain, 20x) of spleen in rats induced Rhodamine B. A: white pulp; B: red pulp; C: trabecula.

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Molecular docking

Our finding predicted that the best binding energy score of the compounds of Pirdot, for instance ursolic acid, maslinic acid, and corosolic acid, against Protein spleen tyrosine kinase (Fig.2) ranges from - 13.6 to -13.8 kcal/mol. In contrast, Doxorubicin as compound control was at -10.8 kcal/mol, summarized in Table 2. Besides, the selected compound of Pirdot has range affinity energy= -12.2 kcal/mol to -14.2 kcal/mol bound to the active site of protein MTOR (Fig.3). Moreover, the docking study revealed that bioactive compounds of Pirdot bound to Cx43 with range affinity energy= -12.7 kcal/mol to -13.2 kcal/mol in renal carcinoma shown Fig.4.

Table 2. The binding affinities of bioactive compound against Protein Spleen Tyrosine Kinase, Protein MTOR, and Protein Gap Junction

	Protein Spleen Tyrosine Kinase			**Protein MTOR**			**Protein Gap Junction (Cx43)**		
Compound	Binding Affinities (Kcal/mol)	Hydrogen Bond	Hydro-phobic Interaction	Binding Affinities (Kcal/mol)	Hydrogen Bond	Hydro-phobic Interaction	Binding Affinities (kcal/mol)	Hydrogen Bond	Hydro-phobic Interaction
Beta Sitosterol	-10.4	-	Leu377, Val385, Ala400, Leu501	-10.4	Leu318	Thr174, Trp274	-10.0	-	Leu26, Leu29, Phe30
Corosolic Acid	-13.6	Lys402, Ala451, Gly454	Leu377, Val385, Leu501	-14.2	Thr174, Leu318	Gln225, Trp274	-12.7	-	Pro88, Ile157, Phe161
Doxorubicin	-10.8	Ser379, Lys402, Asp512	Ala400, Leu501	-12.2	Asn46, Leu48, Ser90, Gln225, Arg227	-	-11.7	Ser18, Gly22, Ser27, Thr89, Tyr155, Ser158, Lys162	Leu26, Phe30
Genistein	-7.9	Lys402, Asp512	Val385, Ala400, Leu501	-8.9	Asn46, Leu48, Asn132, Leu318	-	-8.3	Ser18, Tyr155, Ser158, Lys162	Thr89, Tyr155, Ile159
Maslinic Acid	-13.7	Lys402, Ala451	Val385, Ala400, Val433	-14.1	Val316, Leu318	Thr174, Gln225, Trp274	-12.9	-	Pro88, Thr154, Ile157, Phe161, Phe165
Ursolic Acid	-13.8	Lys402, Ala451, Asp512	Val385, Ala400, Leu501	-13.9	Asn132, Leu318	Gln225, Trp274	-13.2	-	Pro88, Ile157, Phe161, Phe165
Oleanolic acid	-7.8	-	Phe382, Val385, Lys402	-10.1	Leu48, Leu318	Asn46, Ala47, Asn87, Glu105, Gln225, Trp274, Val316	-8.4	Tyr92	His95, Phe161

Dietary exposure to xenobiotic, for instance RhB, could trigger inflammatory mechanism and reduce the ability of phagocytes. Spleen has an important role as a defense which involved in immunological function response to toxicity exposure [22]. In the development of hepato-renal carcinoma therapeutic, the potential preventive effect of EEP was evaluated by histopathological measurement and molecular docking. Our finding revealed that RhB (P2) significantly ($p \leq 0.05$) decreased the spleen weight ratio at 1.4617±1.7589 compared to the control group at 1.6983±0.36745, as shown in Table 1.

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However, the administration of EEP at dose of 500 mg/kg BW could normalize the size of the spleen at 1.7017±3.0492 in rats induced RhB groups. Furthermore, the size of white pulp spleen returned to normal when treated with EEP at 90.607±13.627 compared to the RhB treated group at 114.662±20.923. The results were similar to the previous study that revealed that chemoprevention of natural compounds in *Piper nigrum* extract could improve the spleen weight ratio in rats induced toxicity [23].

In addition, the spleen tissue of the control rats demonstrated normal architecture with red and white pulp spleen (Fig. 1). The administration of Rhodamine B for 30 days showed massive damage in white pulp spleen. In contrast, the EEP at dose 500 mg/kg BW relieved RhB toxicity and improved the spleen morphology.

In order to evaluate the binding interaction of the selected active compounds of EEP, molecular docking was conducted against hepato-renal carcinoma integrated spleen. Spleen tyrosine kinase could be a potential molecular key for the therapeutic of hepato-renal carcinoma which contributed in signal transduction of cellular processes [24]. Our results exhibited that the best binding energy score of the compounds of Pirdot, for instance ursolic acid, maslinic acid, and corosolic acid, against Protein spleen tyrosine kinase (Fig.2) ranges from - 13.6 to -13.8 kcal/mol, compared to the control compound, Doxorubicin at -10.8 kcal/mol, summarized in Table 2. Furthermore, the native compound of Pirdot has to be able to bind effectively (range affinity energy= -12.2 kcal/mol to -14.2 kcal/mol) with the active site of protein MTOR (Fig.3) in order to predict the potential of Pirdot to suppress the development of hepatocellular carcinoma [25]. Besides, the docking study was performed to calculate the binding affinity between bioactive compounds of Pirdot and Cx43 (range affinity energy= -12.7 kcal/mol to -13.2 kcal/mol) in renal carcinoma shown Fig.4. The minimum binding scores between bioactive compounds of Pirdot against protein spleen tyrosine kinase, MTOR and Cx43 is close to the control compound Doxorubicin. Our finding suggested that the bioactive compound of Pirdot could be a candidate treatment for hepato-renal carcinoma therapeutic. Therefore, the bioactive compounds of EEP have a potential bioactive compound to suppress the levels of spleen toxicity linked to hepato-renal carcinoma development.

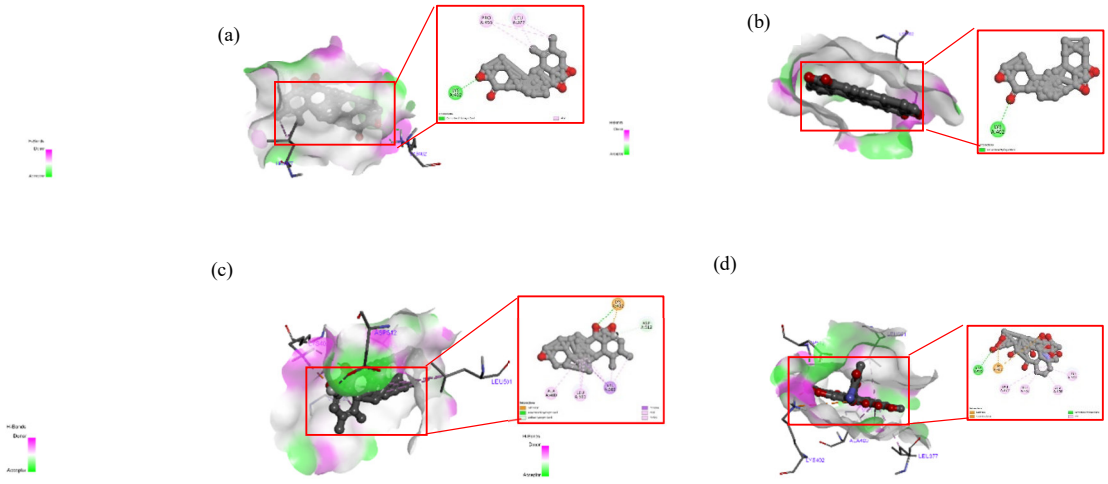

Figure 2. The Molecular docking of bioactive compound against Protein Spleen Tyrosine Kinase (a)Corosolic acid (b) Maslinic acid (c) Ursolic acid (d)Doxorubicin

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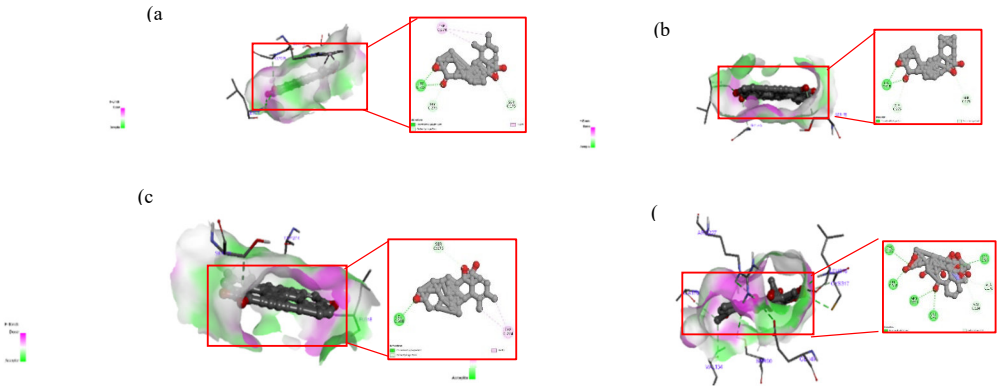

Figure 3. The Molecular docking of bioactive compound against Protein MTOR (a)Corosolic acid (b) Maslinic acid (c) Ursolic acid (d)Doxorubicin

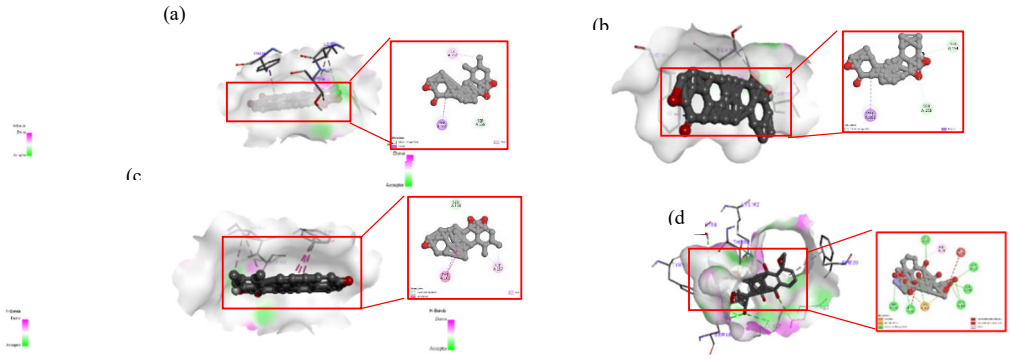

Figure 4. The Molecular docking of bioactive compound against Protein Gap Junction (Cx43) (a)Corosolic acid (b) Maslinic acid (c) Ursolic acid (d)Doxorubicin

Conclusion

The histopathological measurement and molecular docking of *S. vulcani* extract against hepato-renal carcinoma integrated spleen were identified in the present study. The EEP at dose 500 mg/kg could significantly improve the architecture of spleen in RhB treated groups. The outcome of the molecular docking study revealed that evaluated active compounds of EEP have good binding affinities bound to the active site of Protein Spleen tyrosine kinase, MTOR hepatocellular carcinoma, and gap junction of renal carcinoma. It could be concluded that EEP has the potential preventive effect against hepato-renal carcinoma integrated spleen induced RhB in rats.

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Screening of secondary metabolite compounds of medicinal raw materials in Sumatrana Frankincense (*Styrax benzoin*) cultures

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Abstract. *The need for bioactive compounds for medicinal raw materials from plants needs attention to meet the needs of pharmacology and the pharmaceutical industry. Kemenyan Sumatran (Styrax benzoin) is known to produce latex containing bioactive compounds as raw materials for medicine. Bioactive compounds contained in the Styrax benzoin plant have been widely used in pharmaceuticals because phytochemical studies have proven that bioactive compounds are effective as raw materials for medicine. The problem faced is that it takes years for Sumatran Benzoin trees to produce sap. For this reason, it is necessary to study the production of secondary metabolite bioactive compounds in culture. The aim of this study was to screen for the presence of secondary metabolites of medicinal raw materials in Frankincense Sumatrana cultures. The research was conducted through the following stages: (1) In vitro culture of Sumatrana Frankincense at optimum condition of growth regulators, and (2) Isolation, identification and confirmation of plant secondary metabolite contained in Sumatrana Frankincense cultures. The results of the study included the optimum conditions for in vitro culture of Frankincense Sumatrana and its relation to the production of secondary metabolites. The composition of the chemical compounds contained in the in vitro culture was compared to that contained in the frankincense sap. The potential of bioactive compounds in cultivars can reveal the economic value produced by plants at the culture and mature plant levels.*

Keywords: in vitro culture, secondary metabolites, styrax benzoin, medicinal raw materials, forest plants

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Introduction

Secondary metabolites are naturally produced by plants, many of which are bioactive compounds, efficacious for curing various diseases, and after going through a chemical process can be used as raw materials for medicine. Bioactive compounds from plants are excellent for medicine because they are relatively safe for health and reduce the negative impact on environmental pollution [1,2]. Secondary metabolite compounds are used by pharmacology and industry, namely as raw materials for medicines in accordance with increasing demand for reasons of natural availability and safety for the environment [3]. One of the Indonesian forest plants that needs attention and disclosure is Sumatra Frankincense (*Styrax benzoin*), which produces sap containing secondary metabolite compounds as medicinal raw materials [4]. Phytochemical studies confirm that the bioactive compound of Styrax benzoin has been widely used in pharmaceuticals because it is effective in curing various diseases [5,6]. Bioactive compounds from frankincense resin have been widely used for a long time as traditional and modern medicine because they have anti-inflammatory, antioxidant and antibacterial properties [7]. The problem with utilizing Frankincense resin is that it takes tens of years for Sumatrana Frankincense trees to produce sap, making it difficult to produce bioactive compounds for pharmaceutical and industrial purposes, and excessive plant exploitation will have a negative impact on plants [8]. The production of secondary metabolite compounds needs to be done naturally in a relatively short time without sacrificing plant sustainability. One effort to overcome this problem is through the production of secondary metabolite compounds through in vitro culture. The production of secondary metabolite compounds using in vitro techniques is assumed to contain the same bioactive compounds as those produced by plants. Thus, the secondary metabolites produced in the Sumatran Frankincense culture have similarities to the chemical compounds contained in Frankincense sap. The success of the in vitro technique will be able to provide secondary metabolite compounds from medicinal raw materials in a relatively short time.

In vitro culture techniques are generally used for plant propagation because they produce plant seeds with the same quality as the parent plant [9]. The formation of secondary metabolite compounds in culture is commonly found during in vitro culture incubation, and generally occurs in the propagation of medicinal plants, due to active cell division in meristematic cells when using explants from young plant material [10-12]. This strategy can be utilized in the production of secondary metabolites containing bioactive compounds as medicinal raw materials, especially for the Sumatrana Frankincense forest plant [13,14]. Secondary metabolites produced by plants are used as raw materials for medicines [15]. Frankincense sap is known to contain medicinal raw materials such as benzoic acid, cinnamic acid, alkaloids, flavonoids, terpenoids and their derivatives [16]. The bioactive compounds contained in frankincense sap have been used as anti-oxidants, anti-inflammatory, anti-diabetic, anti-cancer, anti-obesity, anti-angiogenic, anti-aging, anti-cancer, and antiseptic [17]. Techniques for isolating and identifying chemical compounds contained in the in vitro culture of Sumatrana Frankincense were carried out to see the potential for producing bioactive compounds from medicinal raw materials from Frankincense cultures. This research aims to screen the bioactive compounds of medicinal raw materials contained in the in vitro culture of Styrax benzoin. Exploration of bioactive compounds from frankincense cultures is very relevant in the production of bioactive compounds from medicinal raw materials contained in secondary metabolites that occur during incubation of in vitro plant cultures.

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Methods

The research procedure was carried out following the stages of in vitro culture and isolation of bioactive compounds as described in previous studies [18,19]. Briefly, the research method consisted of in vitro culture of Styrax benzoin, followed by the screening stage for secondary metabolites contained in the in vitro culture isolate of Sumatrana Frankincense.

In vitro culture of Sumatran Frankincense

The research used a completely randomized design to obtain optimum conditions for culture growth with variations in the concentration of growth regulators, namely a combination of treatments with variations in the concentration of the regulator indolebutryic acid (IBA)/naphthaleneacetic acid (NAA) [4].

The explants are the leaves of the best mother plant of the Sumatran Frankincense tree, harvested directly from the forest area in Pergetteng-Getteng, Sengkut District, Pakpak Bharat Regency, North Sumatra, Indonesia. The explant material is then treated for in vitro culture techniques to produce callus culture. In vitro culture starts from preparing plant material, providing culture media, sterilizing explants, planting explants in the media, and observing the growth and development of the culture from explants to callus. Explant pieces from young plant shoots were cut at the apical end, then planted in hardened MS basal media (8% bacto agar) with the addition of varying concentrations of growth regulators [20-22]. Incubation was carried out in a rack, 1000 lux illumination for 16 hours/day, with a temperature setting of 25-27 ºC. The next stage is harvesting the in vitro culture to be used as raw material for isolation and screening of secondary metabolite compounds.

Screening for secondary metabolite compounds

In vitro culture products are treated by drying, grinding and storing the raw materials in a desiccator to minimize water content. The dried samples were dissolved, isolated and continued to screen for bioactive compounds [23,24]. The sample is dissolved in ethanol, refluxed and evaporated until dry, extracted using a solvent to produce a filtrate, then acidified with HCl or alkalized with NaOH, then extracted using diethyl ether, and purified. The pure isolate was screened using Gas Chromatography Mass Spectrometry (GC-MS) [19].

Results and Discussion

In vitro production of secondary metabolites

In vitro culture of *Styrax benzoin* plants was carried out using explants from the best parent plants. Callus production from culturing plant explants in planting media is shown in Figure 1. Callus formation in culture media is influenced by the concentration of growth regulators in the media. The formation of secondary metabolite compounds in the media is in line with the growth and development of living plant tissue in the culture media. The callus is then harvested as raw material for the isolation of secondary metabolites. The pure isolate obtained from isolation and extraction is then screened to identify the presence of secondary metabolite chemical compounds which are classified as medicinal raw materials. Callus was obtained from the results of incubation of explants in the media. The quality of callus growth in Sumatrana Frankincense culture is greatly influenced by variations in the concentration of growth regulators added to the media. The callus formed can be harvested after seven weeks. The callus produced by in vitro culture of Sumatrana

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Frankincense in culture media is shown in Figure 2. The percentage of live culture is relatively high (70-80%). The product in the form of callus culture is then used as raw material for the isolation and screening of secondary metabolite compounds.

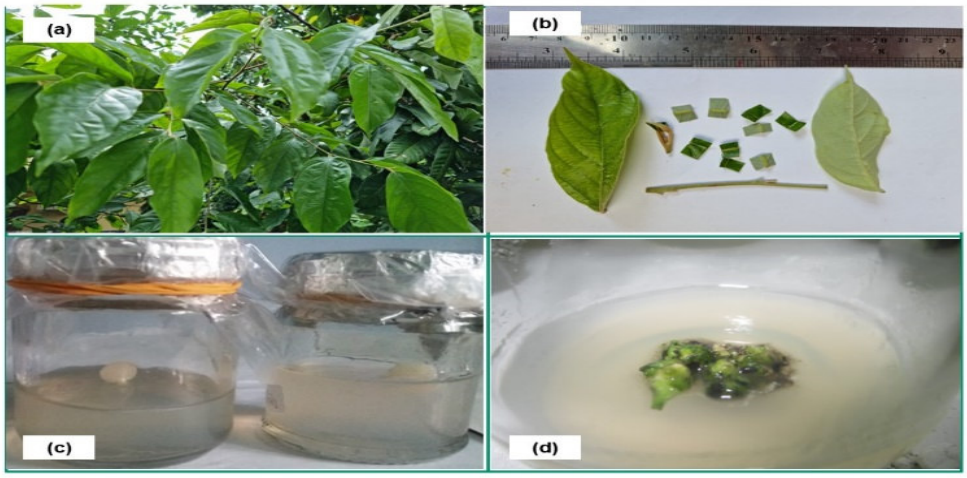

Figure 1. Production of secondary metabolites in *Styrax benzoin* culture through callus growth and development: (a) Young leaves from the parent plant, (b) Explants from young leaves, (c) callus growth in the media, (b) Callus ready to be harvested

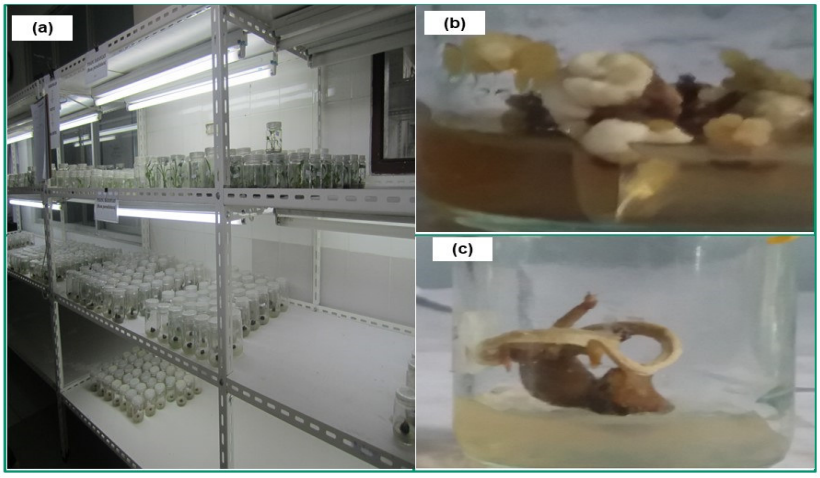

Figure 2. Types of callus growth in *Styrax benzoin* culture as raw material for isolating secondary metabolites: (a) incubation in the culture room, (b-c) types of growth and development of explants into callus ready for harvest

Isolation and screening of secondary metabolite

The isolate obtained from the frankincense culture has been purified and analyzed qualitatively to ensure the presence of secondary metabolite compounds. The chemical compound isolated from the largest fraction is in the form of an oily solution, and gives a distinctive aroma. The results of qualitative analysis showed that the isolates were positive for containing bioactive compounds. Description of the results of qualitative analysis of secondary metabolite compounds and estimates

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of the quantity of chemical compounds contained in frankincense cultures are summarized in Table 1.

Table 1. Qualitative analysis of secondary metabolite compounds from in vitro culture isolates of Sumatrana Frankincense

No	Secondary metabolite compounds	Properties		Composition (%)
		Physical properties	Chemical properties	
1	Largest fraction (Benzoic acid)	The chemical compound is in the form of a yellowish-white liquid and emits an aroma	The compound dissolves in chloroform, ether, ethanol, methanol, and hot water.	0,1%
2	Some chemical compounds	They have not been analysis	They have not been analysis	NA

Screening techniques are carried out to identify and confirm the names of chemical compounds contained in isolates that have been analyzed qualitatively. Secondary metabolite compound screening was carried out using GC-MS by comparing it to the spectrum data bank available in the instrument. The screening results were used to predict the names of chemical compounds contained in the Sumatrana Frankincense culture. Due to the problem of insufficient quantity of isolates (low quantity of isolates), infrared analysis (FTIR) was not carried out, namely the data needed to help identify the presence of functional groups and chemical bonds in chemical compounds. The confirmation of the chemical compounds contained in the in vitro culture isolates has been successfully carried out and the GC-chromatogram and MS spectrum were obtained as shown in Figure 3. Identification of chemical compounds based on the peaks of the GC chromatogram and MS spectrum of the isolates shows the similarity of peak patterns in the GC chromatogram and spectrum-MS of benzoic acid compounds [19]. The results of this analysis provide confirmation of the presence of secondary metabolites of benzoic acid.

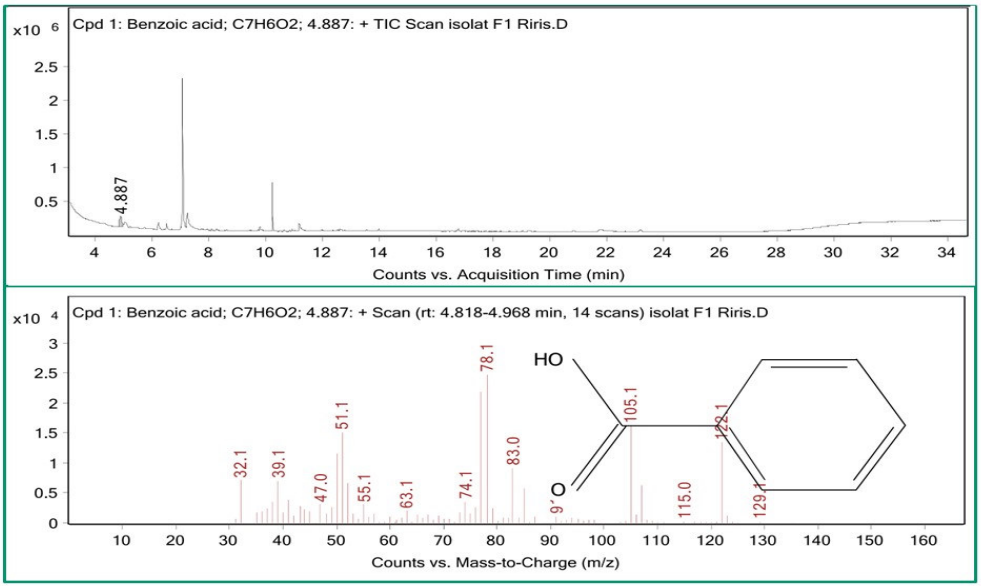

Figure 3. Screening of secondary metabolite compounds contained in the in vitro culture of Sumatran Frankincense: (a) chromatogram-GC, (b) spectrum-MS

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The growth and development of in vitro culture of Sumatrana Frankincense gave encouraging results. From the experimental results, it is known that the optimum conditions for producing large amounts of callus with very good growth intensity are the supplementation treatment of 3 mg/L NAA and 3 mg/L NAA into the basal medium. The percentage of explants growing into callus in the media when supplemented with variations of BAP and NAA under optimum conditions is very high. These results consistently demonstrate the role of growth regulators in callus growth and development [25,26]. Basal media enriched with BAP and NAA can induce callus in large quantities with varying types of callus growth. The callus formed has been harvested and used as raw material for screening secondary metabolite compounds. Isolation and identification of secondary metabolite compounds in in vitro culture of Sumatran Benzoin plants was successfully carried out. Isolation of secondary metabolite compounds from callus culture is difficult because the quantity of chemical compounds contained is very small. To obtain isolates, the preconcentration step is carried out repeatedly until sufficient isolates are obtained for GC-MS analysis.

Producing secondary metabolite compounds in Sumatrana Frankincense culture is an excellent strategy for producing bioactive compounds from medicinal raw materials. Secondary metabolite screening results from in vitro culture of Sumatran Frankincense showed encouraging results. Qualitative analysis using GC-MS shows the presence of several bioactive compounds in small amounts, and has been identified based on the instrument data bank as benzoic acid [19]. The success of this research reveals the potential of in vitro culture techniques in the production of bioactive compounds from medicinal raw materials of high economic value. More detailed studies still need to be carried out to confirm the presence of the bioactive compound benzoic acid in the callus culture to reveal and explain scientific information about whether the secondary metabolites found are the result of biosynthesis during the incubation process in the culture medium. Another possibility that needs to be ascertained is whether the secondary metabolite compound found in the Sumatrana Frankincense culture isolate is benzoic acid which is already in the explant of the culture raw material. However, so far the confirmation of the presence of benzoic acid compounds in *Styrax benzoin* cultures has provided opportunities for the potential of in vitro cultures in producing secondary metabolite compounds. From the screening results, several other compounds were also obtained that needed to be identified because they may not yet be in sync with the data available in the automatic enumeration from the Instrument data bank. Another possibility is that the concentration of chemical compounds is so low that it cannot be identified by the instrument software automatically. Based on previous studies, it is known that the sap produced from the Sumatran Frankincense plant contains large amounts of benzoic acid compounds, which are classified as medicinal raw materials [27-29]. The economic potential of Sumatran Frankincense culture is very large in producing secondary metabolites that have high economic value [30-32]. The success of this research in the opportunity to produce bioactive compounds using in vitro culture in the laboratory is very profitable so that excessive exploitation of forest trees can be avoided.

Conclusion

The strategy of producing secondary metabolite compounds through in vitro culture is very appropriate to accelerate the production of bioactive compounds from natural medicinal raw materials. In vitro culture of Sumatrana Frankincense (*Styrax benzoin*) has been carried out under optimum treatment conditions to produce callus as raw material for the isolation of bioactive

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compounds. Isolates from *Styrax benzoin* cultures have been obtained and have been qualitatively analyzed and contain positive bioactive compounds. Screening results using GC-MS confirmed the presence of benzoic acid compounds in the in vitro culture of Sumatrana Frankincense. The success of in vitro culture to produce secondary metabolite compounds found in this study is a good strategy, and is the first to be successfully carried out to produce chemical compounds from medicinal raw materials from Sumatrana Frankincense culture. The successful production of secondary metabolites using in vitro techniques is an effective strategy for producing bioactive compounds naturally without sacrificing the parent plant, so that the need for medicinal raw materials can be realized in a relatively short time.

Acknowledgment

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Macroinvertebrate diversity as a bioindicator of the water quality in the Belumai River, Deli Serdang Regency, North Sumatra

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Abstract. *Macroinvertebrates are invertebrate organisms whose habitat is in the water, usually attached to water and mud and can describe the physical, chemical, and biological conditions of waters so that they are used as bioindicators of water quality. This study aims to determine the quality of Belumai River waters in Deli Serdang Regency based on the macroinvertebrate diversity index. The research was conducted from January 2022 to March 2022. This research was conducted using 4 stations located in Belumai River. Station 1 is located in a natural area, Station 2 is located in a plantation area,Station 3 is a sand dredging area, and station 4 is an industrial and residential area. Each station uses 6 sampling points, namely the right bank point, the middle point and the left bank point of the river, so that the number of sampling location points is 24. The results showed that macroinvertebrates found in Belumai River were 4 classes, 7 orders, 10 families, and 14 species. The water quality of Belumai River based on the diversity index is included in the moderately polluted category (H'= 1.27-2.33). This research is expected to provide information related to the potential of macroinvertebrates in identifying water quality.*

Keywords : Macroinvertebrates, bioindicators, Belumai River, water quality

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Introduction

Rivers are natural flowing water ecosystems that play a vital role for humans and other organisms. They serve as habitats for various aquatic organisms such as fish, shrimp, and mollusks. Rivers are also valuable as they provide water for daily human activities, agriculture, and industries [1]. Water quality can be assessed using physical and chemical parameters. Additionally, biological parameters can be used to determine water quality by examining the biota present in the river. Biota that can be used as indicators to assess the condition of water quality are organisms that can respond to the presence of pollutants [2] Bioindicators are organisms capable of indicating the location, status, and quality of the environment.

One group of biota that inhabit water bodies and can be used as indicators of water pollution is macroinvertebrates, also known as macrozoobenthos [3]. Macroinvertebrates can provide indications of pollutant presence, as certain species are highly sensitive to pollution [4]. Macroinvertebrates are invertebrate organisms that inhabit the seabed and river bottoms, usually attached to water and mud. They can reflect the physical, chemical, and biological conditions of water bodies, making them useful as bioindicators of water quality [5].

Belumai river is one of the rivers in Deli Serdang Regency, North Sumatra Province, Indonesia. Activities along the Belumai River include industrial, agricultural, and residential activities. The local community still uses the river for bathing, washing, and sanitation purposes. There are 12,397 industrial units in Deli Serdang Regency, ranging from large-scale to small-scale industries, including paper mills, poultry farms, palm oil machinery assemblers, glove factories, wood factories, metal casting factories, and textile factories [6]. These industries likely discharge both treated and untreated wastewater into the Belumai River, which may have an impact on the changing water quality. The numerous activities occurring in the Belumai River, both domestic and industrial, resulting in pollutant discharge, can affect the physical, chemical, and biological factors.

The deteriorating water quality in the Belumai River due to various activities and the habit of the local community dumping waste into the river can have negative effects. If these practices continue, water quality will further decline. The declining water quality in the Belumai River will affect the life of biota, especially macroinvertebrates. Therefore, research on the diversity of macroinvertebrates is needed to serve as an indicator of the river's condition, enabling proper management of the Belumai River's water resources.

Methods

Location and time of research

The research was conducted from January 2023 to April 2023 in the Belumai River watershed, Deli Serdang Regency (Station 1 and 2 located in the STM Hilir sub-district, stations 3 and 4 located in the Tanjung Morawa sub-district). Macroinvertebrate identification will be carried out at the Biology Laboratory of Medan State University. Physical and chemical water parameters such as temperature, clarity, depth, and pH will be measured in situ or directly in the field, while water quality measurements based on chemical indicators will be conducted at the BTKLPP Medan Laboratory.

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Population & Sample

The population in this study is all macroinvertebrate species in the Belumai River ecosystem, Deli Serdang Regency. The samples used in this study are macroinvertebrates found at the research stations and water samples from each research station in the Belumai River, Deli Serdang Regency.

Determination of Location Points

The research location points are determined based on the environmental conditions surrounding the Belumai River. The study will be conducted using 4 stations. The first station is located in a natural area (with vegetation on both sides of the river). The second station is located in an agricultural and plantation area. The third station is located in a sand mining area, and the fourth station is located in an industrial and residential area. Each station will have 6 sampling points: right bank, middle, and left bank of the river, resulting in a total of 24 sampling points.

Macroinvertebrate Sampling

Macroinvertebrates will be collected using Surber nets, Eickman Grabs, or by hand if the sediment is soft or muddy. Surber nets can also be used in rocky areas. The collected samples suspected to contain macroinvertebrates will be placed in containers. Subsequently, the macroinvertebrates in the containers will be fixed with 10 drops of 4% formalin. The samples will then be transported to the laboratory, where they will be rinsed on a sieve under running water. Cleaned macroinvertebrates will be transferred to containers containing 70% ethanol. The prepared macroinvertebrates will be identified using a prepared identification book. All stages of the process will be documented.

Measurement of Physical & Chemical Indicator

Water temperature will be measured using a thermometer by immersing it in the water. The reading will be recorded. Clarity will be measured using a Secchi disk attached to a marked wooden stick. The Secchi disk will be lowered into the river until it is no longer visible. The length of the submerged part will be measured and recorded. River depth will be measured using a marked wooden stick. The stick will be inserted into the river until it touches the riverbed, and the depth will be determined by the submerged length of the stick. The measurement will be recorded. Flow velocity will be measured using a floating ball. A 10-meter rope will be attached to a plastic ball, which will be placed on the water surface. The time it takes for the ball to move a distance of 150 cm from the starting position will be measured using a stopwatch. The flow velocity will be measured at the left bank, middle, and right bank, and the average value will be recorded. The flow velocity will be calculated by dividing the distance (150 cm) by the time recorded on the stopwatch.

Water samples for chemical analysis will be collected simultaneously with macroinvertebrate sampling. Parameters to be analyzed include water pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). In situ measurements of pH will be conducted using a pH meter, while DO, BOD, and COD measurements will be performed at the BTKLPP Medan Laboratory (Environmental Health and Disease Control Technical Center).

Data Analysis

The diversity index (H') describes the population's condition mathematically to facilitate the analysis of the number of individuals of each species in a community. Calculation is done using

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the equation from Shannon-Wiener [7]. The evenness index, based on the Shannon-Wiener function, is used to determine the distribution of each macrobenthic animal species within the observation area.

Results and Discussion

Sampling was carried out at 4 different stations, and macroinvertebrate identification results were obtained which can be seen in Table 1.

Table 1. Macroinvertebrate data found in the Belumai River

No	Species	Number of Individuals			
		Station I	Station II	Station III	Station IV
1.	***Ghompus* sp.**	**-**	**1**	**4**	**6**
2.	*Melanoides tuberculata*	1	5	-	1
3.	*Gerris remigis*	-	16	22	-
4.	*Palaemonetes varians*	-	9	27	15
5.	*Lumbriculus variegatus*	-	-	-	30
6.	*Nososticta insignis*	-	3	1	3
7.	*Thiara scabra*	3	7	-	2
8.	*Thiara winteri*	1	1	-	6
9.	*Goniobasis hydei*	3	10	1	-
10.	*Terebia granifera*	5	6	1	2
11.	*Physa gyrina*	-	-	-	3
12.	*Bellamya* sp.	5	1	-	-
13.	*Limnodrilus*	-	11	-	5
14.	*Lumbricus rubellus*	3	9	-	4
	Total	21	79	56	77

Table 1 above shows the macroinvertebrate data found in the Belumai River, consisting of 14 species. The number of macroinvertebrates obtained varies at each research station. The lowest number of individuals is found at station I, with 7 species and a total of 21 individuals. Meanwhile, the highest number of individuals is found at station II, with 12 species and a total of 79 individuals. The identified macroinvertebrate data is then analyzed to determine the diversity index (H'), evenness index (E), and dominance index (C). The Shannon-Wiener index is used as a reference for diversity and evenness analysis, while the Simpson index is used as a reference for dominance analysis. Each index is analyzed using predetermined formulas. The results obtained for the diversity index (H'), evenness index (E), and dominance index (C) are presented in Table 2.

Table 2. Results of diversity index, uniformity index, and dominance index values

Index	Station				Level
	I	II	III	IV	
Shannon Wienner Diversity (H')	1.81	2.23	1.12	1.91	<1 Low diversity 1-3 Medium diversity >3 High diversity
Shannon Wienner Uniformity (E)	0.93	0.90	0.63	0.80	<1 Low uniformity >1 High uniformity
Simpson Domination (C)	0.18	0.12	0.39	0.21	00.0 < C ≤ 0.30 Low dominance 0.30 < C ≤ 0.60 Medium dominance 0.60 < C ≤ 1.00 High dominance

Based on the observations in Table 2 above, the diversity index values at stations I, II, III, and IV range from 1.12 to 2.23. These values indicate that the diversity index at each station falls

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within the moderate diversity category. The evenness index values for all stations range from 0.63 to 0.93, indicating E<1. E<1 signifies low evenness at each station. The dominance index values at stations I, II, and IV range from 0.12 to 0.39, indicating low dominance. On the other hand, the dominance index value at station III is 0.39, indicating moderate dominance.

The physical indicators measured in this study include temperature, brightness, depth, and current velocity of the Belumai River. The results of the physical indicator measurements are presented in Table 3.

Tabel 3. Physics Indicator Analysis Data

Indicator	Station				Standards Quality
	I	II	III	IV	
Temperature	28	27,3	28,3	27,6	38°C
Brightness	16	32,5	2,4	11,8	<6 m
Depth	47,7	31,7	66,3	64	-
Velocity	0,2	0,3	0,4	0,3	-

Based on Table 3, it can be determined that the results of the physical indicator measurements at the four stations are varied. The temperature measurements at the research stations range from 27.3°C to 28.3°C. The brightness measurements at the research stations range from 2.4 cm to 32.5 cm. Furthermore, the depth measurements at the research stations range from 31.7 cm to 66.3 cm. The current velocity measurements at the research stations range from 0.2 m/s to 0.4 m/s. The water quality measurements in the Belumai River, Deli Serdang Regency, in this study include pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). The results of each indicator measurement are presented in Table 3.

Tabel 4. Chemistry Indicator Analysis Data

Indicator	Station				Water Quality Standard according to PP No.82 of 2001 Class II
	I	II	III	IV	
pH	6,8	6,5	6,7	6,5	6 - 9
DO	4.8	5	4,3	4,7	4 mg/l
BOD	1,4	1,4	1,6	6,6	3 mg/l
COD	8,3	6,3	7,4	17,3	25 mg/l

Based on Table 4, it can be seen that the measurements of chemical parameters at the four research stations in the Belumai River are as follows: the pH ranges from 6.5 to 6.8. The measurement of dissolved oxygen (DO) at the research stations ranges from 4.3 to 5 mg/l. The measurement of biochemical oxygen demand (BOD) at the research stations ranges from 1.4 to 6.6 mg/l. The highest measurement of chemical oxygen demand (COD) is found at station IV, which is 17.3 mg/l, while the lowest measurement of COD is found at station II, which is 6.3 mg/l.

Biological Indicator

The use of biological indicators is one way to assess the condition of a water body. One commonly used biological indicator is macroinvertebrates, as they have a long lifespan, slow locomotion, and inhabit specific areas. The data of macroinvertebrates found at each station in the Belumai River is presented in Table 5.

Based on the table above, it can be seen that the macroinvertebrate data found at each station in the Belumai River consists of four different classes: Gastropoda, Insecta, Oligochaeta, and

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Crustacea. In the Gastropoda class, the macroinvertebrates found are grouped into two orders: Megastropoda and Basommatophora. Under the Megastropoda order, there are four families, including Viviparidae, Thiaridae, Pleurocenidae, and Physidae. In the Basommatophora order, there is one family, Physidae. In the Insecta class, the macroinvertebrates found are grouped into two orders: Odonata and Hemiptera. Under the Odonata order, there are two families, Gomphidae and Protoneuridae. Meanwhile, under the Hemiptera order, there is one family, Gerridae. In the Oligochaeta class, the macroinvertebrates found belong to two orders: Chaetopoda and Haplotaxida. Under the Chaetopoda order, there is one family, Lumbriculidae. In the Haplotaxida order, there is only one family, Tubificidae. Lastly, in the Crustacea class, only one family is found, Palaemonidae. Based on the analysis of the diversity index values using the Shannon-Wiener index formula, the results at stations I, II, III, and IV show that the diversity index reaches H' = 1. Overall, it can be said that the Belumai River has a moderate diversity index value.

Tabel 5. Classification of Macroinvertebrates in the Belumai River

Classis	Ordo	Family	Genus	Species
Gastropoda	Megastropoda	Thiaridae	Melanoides	*Melanoides tuberculata*
			Thiara	*Thiara scabra*
				Thiara winteri
			Tarebia	*Terebia granifera*
		Viviparidae	Bellamya	*Bellamya* Sp.
		Pleurocenidae	Goniobasis	*Goniobasis hydei*
	Basommatophora	Physidae	Physa	*Physa gyrina*
Insecta	Odonata	Gomphidae	Ghompus	*Ghompus* sp.
		Protoneuridae	Nososticta	*Nososticta insignis*
	Hemiptera	Gerridae	Gerris	*Gerris remigis*
Oligochaeta	Chaetopoda	Lumbriculidae	Lumbricus	*Lumbricus rubellus*
			Lumbriculus	*Lumbriculus variegatus*
	Haplotaxida	Tubificidae	Limnodrilus	*Limnodrilus*
Crustacea	Decapoda	Palaemonidae	Palaemon	*Palaemonetes varians*

The biodiversity index values in the Belumai River indicate that the river is experiencing ecological pressure and a decline in ecosystem stability, leading to a decrease in the distribution of macroinvertebrate communities. The ecological pressure in the Belumai River is likely attributed to the daily activities of the local residents. Table 4.2 shows that the highest biodiversity value, 2.33, is found at station II, located in the plantation area. The high diversity of macroinvertebrates at station II is due to the availability of necessary nutrients for their survival, suggesting that the water quality at station II is slightly polluted. On the other hand, the lowest biodiversity value, 1.27, is found at station III, located in a residential area and including sand excavation sites, indicating that the water quality at station III is relatively polluted. Based on the analysis of the evenness index using the Shannon-Wiener index formula, the values range from E=0.65 to E=0.93 for all stations. These values indicate that the evenness at each station is low, and the distribution of each species in the respective stations is becoming uneven. The low evenness index values in the Belumai River indicate that the biota in that area are less tolerant to the pollutants entering the water. If a biota community lacks tolerance to pollutants in the river, it

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may relocate to areas with fewer pollutants or to areas where the pollutants can still be tolerated by the biota community.

The species dominance index in the Belumai River ranges from 0.11 to 0.36, indicating that the dominance of macroinvertebrates in the river is considered low. The dominance index shows that there is no species domination at each research station. The values range from 0.11 to 0.36. The criteria for the dominance index range from 0 to 1. A dominance index of 0 indicates the absence of species dominance, while a dominance index approaching 1 suggests that one species dominates the community. However, there are some species that tend to be dominant at each research station, with their population density being higher compared to other species. The dominance index (C) is used to determine the extent to which a group of biota dominates, and a significant dominance can lead to a fragile or stressed community.

Physics Indicator

The physical indicators obtained consist of temperature, clarity, depth, and flow velocity. Based on the research conducted, it is known that the temperature at each station during the study period is within the normal range, ranging from 27.3°C to 28.3°C. Station I recorded a temperature of 28°C, station II recorded 27.3°C, station III recorded 28.3°C, and station IV recorded 27.6°C. The variation is likely due to differences in sampling time and environmental conditions at each station. In this study, the results obtained are compared to the water quality standard set by Regulation No. 82 of 2001. According to this regulation, the maximum water temperature limit is 38°C, indicating that the results obtained in this study are still in accordance with the established water quality standard.

The measurements of clarity obtained at all stations in the Belumai River range from 2.4 cm to 32.5 cm. Based on the water quality standard for clarity (<6m), the results obtained for clarity measurements at all research stations indicate that the river is not polluted. Based on the measurements of depth obtained at the four research stations in the Belumai River, the shallowest depth is found at station II. Station II is the shallowest location because it is situated in a hilly area, and the riverbed consists of sand and rocky particles. The shallow condition of the river area can lead to several negative impacts, such as flooding. This is caused by an increase in surface water flow and reduced water absorption into the ground due to the accumulation of sand and rocky particles on the riverbed.

The flow velocity in the Belumai River at the four stations ranges from 0.2 to 0.4 m/second. This indicates that the river falls under the category of moderate flow, according to Mason (1993), who classified water bodies with flow rates greater than 1 m/s as very fast, flow rates between 0.5-1 m/s as fast, flow rates between 0.25-0.5 m/s as moderate, flow rates between 0.1-0.25 m/s as slow, and flow rates less than 0.1 m/s as very slow.

Chemistry Indicator

The chemical indicators used in this study consist of pH, DO, BOD, and COD. The pH measurements obtained from all research stations in Sungai Belumai ranged from 6.5-6.8, indicating that the river still has a normal pH level for aquatic organisms. The DO (Dissolved Oxygen) values obtained at each research station were in the range of 4.3-5 mg/l. According to Barus (2004), the ideal range for dissolved oxygen in water should be between 6-8 mg/l, and lower DO values indicate higher levels of ecosystem pollution. The DO levels above are considered

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sufficient for supporting organism life, as stated by Sinambela (1994), as long as no toxic compounds are present.

BOD values are an indicator of pollution in water. The BOD values at all research stations ranged from 1.4-6.6 mg/L, with the highest value at station IV and the lowest at stations I and II. The BOD level is influenced by the amount of organic matter dissolved in water. BOD testing is necessary to determine the pollution load from wastewater and design biological treatment systems for polluted water, as mentioned by Sukadi (1999).

The average COD value in Sungai Belumai during the study ranged from 6.3-17.3 mg/l. The highest COD value was found at station IV, located in an industrial and residential area, while the lowest value was at station II, which is an agricultural area. Based on the measurements of physical and chemical water quality indicators, Sungai Belumai falls into class II and III according to the water quality standards set by PP. No. 82 of 2001 on Water Quality Management and Pollution Control, which allows the river to be used for freshwater fish farming, livestock, and irrigation. According to Article 14(1) of PP. No. 82 of 2001, water is considered polluted if its quality does not meet the set standards, and it is considered good if it meets the standards [9].

Conclusion

Based on the research results, data analysis, and discussion, the conclusion drawn is that the level of macroinvertebrate species diversity based on the Diversity Index obtained in Sungai Belumai, Deli Serdang Regency, is H' = 1, indicating a moderate level of macroinvertebrate diversity in the river. The water quality of Sungai Belumai, Deli Serdang Regency, assessed based on the diversity index, indicates that the water quality is moderately polluted.

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Immunomodulatory activity of ocimum americanum l. Leaves against free-range chicken infected with eimeria tenella with cecum structure parameters

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Abstract. *Free-range chicken business tends to face affect the immune system. This innate trait causes many impacts such as poor production and high mortality rates. One disease that is often found in chickens caused by bacteria is coccidiosis (diarrhea). Coccidiosis is a dysentery disease caused by bacteria and can damage the digestive tract in chickens. Basil contains secondary metabolites with enormous potential. To extract the secondary metabolites of these plants, the researchers used the maceration extraction method using ethanol as a solvent, which would later be able to separate polar compounds such as flavonoids, saponins and terpenoids. Soaking of the extract was carried out to ensure that the desired compound was dissolved in the ethanol. The extract was tested on test animals, namely native chickens which were divided into 5 groups, each of which received different treatment. Each treatment was AN, which was the group that was not given bacteria or plant extracts, AP, which was the group that was given bacteria, EO, which was the group that was given bacteria and basil extract. The body weight is examined and the target organ in the form of the cecum is slowly lifted and weighed to observe the structure of the cecum. The results obtained were that there was a clear effect of giving basil extract on the coecum of chickens, where each dose showed a difference, and the most influential dose was 0.10%, this shows that the accuracy of the dose affects changes in the cytopathological structure of the cecum in chickens*

Keywords: Immunomodulator, Ocimum Americanum L, cecum, Eimeria Tenella

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Introduction

The poultry sector in Indonesia, especially free-range chicken, is a business developed by small breeders in rural areas as a side business and is managed traditionally. However, in this way the farmer's profit is very small, because the business has not yet led to a commercial business [1]. Free-range chicken business tends to face many obstacles, such as easy disease and stress factors that can affect the immune system. This innate trait causes many impacts such as poor production and high mortality rates [2]. The nutrition produced from free-range chicken meat and eggs is generally better because the food is not mixed with chemicals. One disease that is often found in chickens caused by parasitic protozoa is coccidiosis (diarrhea). Coccidiosis is a dysentery disease caused by protozoa and can damage the digestive tract in chickens, although in general this disease can be overcome, based on Poultry Indonesia (2007), the costs required are very expensive, even in a study it was stated that it reaches US $ 300 million per year. According to [3], the death of chickens on a farm due to coccidiosis can reach 5-10% even coccidiosis can cause death up to 100%, if there is a severe infection characterized by a large amount of blood loss. Adult chickens that do not show clinical signs of coccidiosis can act as carriers of coccidia in young chickens [4]. Based on research conducted by [5] on the results of examining 693 samples of free-range chicken feces during 1992-1993, collected from regencies in South Kalimantan, including Hulu Sungai Selatan, Hulu Sungai Tengah, Tapin and Tanah Laut, showed that the average prevalence of coccidiosis (*Eimeria sp*) infection in young chickens is relatively higher than that of adult chickens, while the prevalence of coccidiosis by Eimeria tenella in young chickens is relatively lower than that of adult chickens.

Currently, one of the visions of Medan State University is to develop Unimed to become a superior teaching and research institution. In an effort to overcome community problems including problems in agriculture and animal husbandry, the UNIMED Research and Community Service Institute (LPPM) has a strategic plan that is realized through Basic and Applied Research including botanical and biological processing for medicinal raw materials, vegetation-based herbal medicines, utilization of metabolites for drugs and vaccines.

Basil plants have antidiabetic, antibacterial and antihyperglycemic effects and have antioxidant effectiveness. This basil plant contains flavonoids, tannins, and essential oils that are antibacterial. Essential oil is the most important ingredient in basil. Content Essential oil in basil leaves is able to inhibit the growth of Staphylococcus aureus, Escherichia coli, Bacillus cereus, Pseudomonas fluorescens, Candida albicans, Streptococcus alpha and Bacillus subtilis bacteria. Based on the Phytochemical Screening of extracts on Basil Leaves (Ocimum basilicum.L) it has chemical compounds belonging to the alkaloid group, phenolic compounds, tannins, lignins, saponins, flavanoids, phytosterols, essential oils, anthraquinones and terpenoids [6]

Immunomodulators are substances that can regulate the immune system, either in the form of restoring and repairing the immune system whose function is impaired or to suppress those whose function is excessive. Immunomodulators work in three ways, namely through immunorestoration, immunostimulation, and immunosuppression [7] Most of the medicinal plants that have been studied prove the existence of immunostimulatory action, while for immunosuppressors it is still rare. The use of medicinal plants as immunostimulators with the intention of suppressing or reducing intracellular viral and bacterial infections, to overcome immunodeficiencies or as a stimulant for the growth of the body's defense cells in the immune system [8].

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According to [9] Compounds that have good prospects that can increase the activity of the immune system are usually from the class of flavonoids, curcumin, limonoids, vitamin C, vitamin E (tocopherol) and catechins. In vitro test results of the flavonoids flavones and flavonols have shown an immune response. Aldi 2014, also stated that flavanoid content has the potential as an antioxidant in tumor growth, can increase the immune response and work against lymphokines produced by T cells so that they will stimulate phagocytic cells to carry out a phagocytic response. So based on the chemical content contained in basil leaves, namely flavanoids, a study was carried out on the Immunomodulatory Activity of Ocimum Americanum L Leaf Extract on Kampung Chicken Infection with Eimeria Tenella with Parameters of Activity and Phagocytosis Capacity of Macrophages Cells.

Research Method

This research was carried out in several places and consisted of several stages. Place and stages of research This type of research is experimental research with Completely Randomized Design (CRD). 25 chickens were divided into five treatment groups and each treatment was given 5 replications.

1. Treatment of the AN group

On the 14th day the chickens were given food and drink every day and their weight was measured every day at 16.00 WIB. And then each chicken was weighed every 3 days during the treatment

2. AP group treatment

On the 14th day the chickens were given food and drink without Ocimum americanum L extract every day and their body weight was measured every day at 16.00 WIB. And then each chicken was weighed every 3 days during the treatment. Then in the 8th week the chickens were infected with bacteria

3. 0.5% EO group treatment

On the 14th day the chickens were given food and drink by administering 0.5% Ocimum americanum L extract every day and weighing was carried out every day at 16.00 WIB. And then each chicken was weighed every 3 days during the treatment. Then in the 8th week the chickens were infected with bacteria

4. 0.10% EO group treatment

On the 14th day the chickens were given food and drink by administering 0.10% Ocimum americanum L extract every day and weighing was carried out every day at 16.00 WIB. And then each chicken was weighed every 3 days during the treatment. Then in the 8th week the chickens were infected with bacteria.

5. 0.20% EO group treatment

On the 14th day the chickens were given food and drink by administering 0.20% Ocimum americanum L extract every day and weighing was carried out every day at 16.00 WIB. And then each chicken was weighed every 3 days during the treatment. Then in the 8th week the chickens are infected with bacteria.

Results And Discussion

The results of examination of 25 chickens each matched the treatment where one control group and 4 groups were treated according to the doses of plant extracts and bacteria given. Of the 5 types of treatment showed different anatomic pathologies. Histopathological examination found a collection of oocytes in the

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epithelium of the cecum, villi necrosis, macrogametocytes, microgametocytes, schizonts, bleeding and macrophage infiltration. Histopathology of the cecum in each group of chickens can be seen in Figure 1.

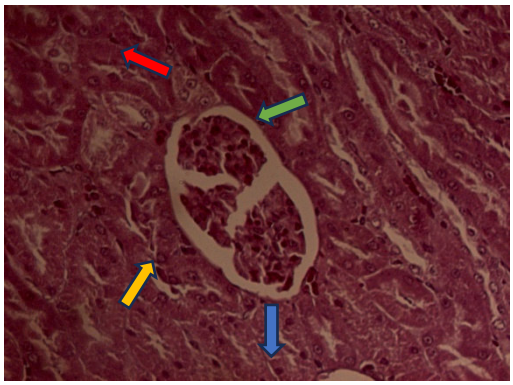

Figure 1 Oosit (Green), Makrofag (Blue), Bloody (Red), Nekrosis (Yelow)

Based on the results of histopathological examination of the cecum of chickens infected with Eimeria tenella, the severity of the cecum found on the mucosa was divided into mild, moderate and severe. Mild intensity if the results of observations found oocysts in several villi accompanied by necrosis of the epithelium. Moderate intensity if the observations found micro and macrogametocytes, necrosis, macrophage infiltration and inflammation. Severe intensity if the results of observations found oocysts, macrophage infiltration, necrosis, inflammation and bleeding, can be seen in Table 1.

Table 1 The level of destruction of the chicken cecum from each sample which was examined histopathologically

No	Histopatology	Broken	Group	Percentace
1	The presence of oocysts accompanied by necrosis of the epithelium	Light	Negative Control = 0 Positif Control = 5 EO 0,05% = 3 EO 0,10% = 1 EO 0,20% = 3	48%
2	Necrosis, macrophage infiltration, inflammation and inflammation.	Medium	Negative Control = 0 Positif Control = 3 EO 0,05% = 3 EO 0,10% = 1 EO 0,20% = 2	36%
3	There were oocysts, macrophage infiltration, necrosis, inflammation and bleeding	Heavy	Negative Control = 0 Positif Control = 5 EO 0,05% = 4 EO 0,10% = 0 EO 0,20% = 4	60%

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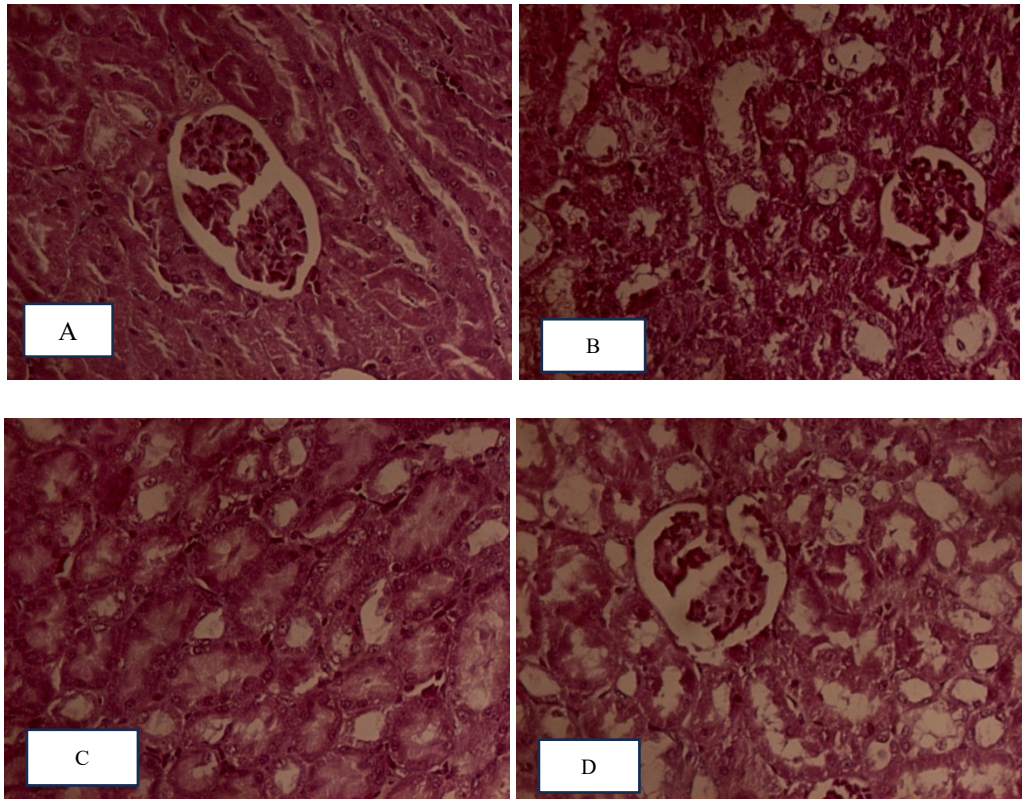

Figure 2 A. Positif Control, B. Group EO 0,05%,

C. Group EO 0,10%, D. Group EO 0,20%

The results of this study were pathological changes in the cecum of free-range chickens that were positively infected with coccidiosis both in anatomic pathology and histopathology. Cecum samples were taken from chickens that were 8 weeks old. This is because the disease is very pathogenic, especially in chickens aged four to eight weeks, while chickens of one to two weeks are more resistant because the oocysts have not been able to be broken down due to weak gastric muscle movement and enzymatic digestion that has not worked optimally, so that the breakdown of the oocyst wall is not perfect. The severity of the mild stage is characterized by the presence of oocysts in the villi of the cecum and necrosis of the epithelium. The severity of the moderate stage is characterized by the presence of oocysts, micro and macrogametes, necrosis, macrophages and inflammation. Meanwhile, the severity of the severe stage is characterized by the presence of oocysts, micro and macro-swelling, necrosis, macrophages, inflammation and bleeding. The percentage of severity of the cecum of chickens infected with *Eimeria tenella* from 25 consecutive samples was mild (48%), moderate (38%) and severe (60%). The severity of the disease depends on environmental factors, chicken immunity, and the large number of Eimeria oocysts ingested. Environmental factors that influence include high humidity in the cage with poor sanitation. This condition will increase the incidence of coccidiosis (Peek and Landman, 2011). If the temperature inside the cage is low and the humidity is high, or the litter conditions are very humid, the sporulating oocysts can then survive in the outside environment for months [10]. Other factors are a feed system that does not contain coccidiostats and poor ventilation and poor cage management where the husks are the damp base of the cage. Examination of the sample begins by looking at the changes that occur in the cecum in anatomical

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pathology. Changes that can be observed are swelling (Figure 1A) and bleeding in the cecal mucosa (Figure 1B). The process that occurs is that the cecum swells and thickens due to the development of the Eimeria schizongony phase.

Tissue changes are also strongly influenced by the infecting Eimeria species and the number of infective oocysts ingested. Judging from the anatomical pathological lesions found in the cecum of chickens, the specific species that infects them is E. tenella. This is supported by Zainuddin [11] that this protozoa attacks the digestive tract of chickens, especially in the cecum. Changes that occur in the cecum are caused by infective oocysts (containing sporozoites) are ingested by chickens and enter the digestive tract. One infective oocyst contains eight sporozoites [12]. The oocyst wall will break after entering the stomach muscle (gizzard) with the help of trypsin enzyme, so that the sporocysts containing sporozoites come out of the oocyst. The trypsin enzyme will degrade the proteins contained in the oocyst wall.

This statement is supported by [13] who said that the components of the oocyst wall. The sporocyst will enter the small intestine. After reaching the small intestine, the sporozoites are activated by trypsin so that the sporozoites exit the sporocysts and enter the cecum epithelial cells. This statement is supported by [14] who said that the sporozoites will come out of the sporocysts in the presence of bile salts and trypsin in the digestive tract. In the merogoni (schizongony) stage, the sporozoites that have entered the cells of the epithelium of the cecum will become rounded, then grow into generation I merons (schizonts), these merons will divide, then each meron will break releasing ± 800 merozoites of generation I with a length of about 2-4μm. The process of rupture of the meron causes damage to the anatomical structure of the cecum. This stage occurs about 2-3,5 days after infection. Generation I merozoites enter new epithelial cells, round and grow into second generation meron. By means of multiple fission, second generation merozoites form second generation merozoites with a length of about 18 μm. At this stage, damage to the structure of the cecum is more severe, characterized by bleeding and necrosis, the cecum will be filled with blood, so that blood is excreted with the stool as seen in Figure 3. It is this blood that is present in the stool causing bloody diarrhea [15] Most of the second generation merozoites enter new epithelial cells to start the sexual phase called gametogony to form gametocytes.

According to [16] the formed gametocytes differentiate into microgametocytes (male) and macrogametocytes (female). So that the histopathological presence of microgametes and macrogametes can be seen in Figure 2 (B) and (D). A number of small, motile microgametes seek out and coalesce with the macrogametes to form a zygote. The resulting zygote will mature and form an oocyst which will be released from the intestinal mucosa and mixed with the feces. The oocyst that can be seen in Figure 2 (A). Histopathological observation of the caecum of chickens also found a number of inflammatory cells. Inflammatory cells found in the cecum organs are macrophages. Macrophages are part of the mononuclear phagocyte system which originates from blood monocytes and has migrated out of the blood vessels and experienced activation in the tissues. Therefore, macrophages are inflammatory cells whose function is to phagocytize microorganisms, in this case Eimeria, as protozoa.

Conclusion

The poultry sector in Indonesia, especially free-range chicken, is a business developed by small breeders in rural areas as a side business and is managed traditionally. This research was carried out in several places and consisted of several stages. Place and stages of research This type of research is experimental research with Completely Randomized Design (CRD). 25 chickens were divided into five treatment groups and each treatment was given 5 replications. The results of this study were pathological changes in the cecum of free-

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Antibacterial Activity Test Against Ethanol Extract of Frankincense Sap (*Styrax benzoin*)

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Abstract. *The Frankincense plant (Styrax benzoin) is a sap that comes from the Frankincense tree which contains flavonoid and tannin metabolites which have antibacterial properties which can inhibit bacterial growth. This research aims to test the activity of benzoin resin by maceration using 96% ethanol solvent. In the antibacterial test, the disc diffusion method was used with various extraction concentrations of 1%, 3%, 5%, 10%, 15%, 20%, 25%. The positive control used was chloramphenicol and DMSO (negative control). The results of this study show that the average zone of inhibition of frankincense sap extract against Staphylococcus aureus bacteria at a concentration of 1% is that there is no zone of inhibition for frankincense gum extract, however at a concentration of 3% there is 12.69 mm, a concentration of 5% there is 16 mm, a concentration of 10% there was 16.50 mm, the 15% concentration had 17.39 mm, the 20% concentration had 18.15 mm, the 25% concentration had 18.53 mm and for the Propionibacterium acnes bacteria the average zone of inhibition of frankincense sap extract was 9.52 mm at a concentration of 1%, 10.41 at a concentration of 3%, 13.46 mm at a concentration of 5%, 14.47 mm at a concentration of 10%, 15.11 mm at a concentration of 15%, 15.87 mm at a concentration of 20% and 16 .25 mm at 25% concentration. The results of this research showed that the average inhibition zone of frankincense gum extract against the bacteria Staphylococcus aureus and Propionibacterium acnes had low inhibition power at small concentrations and had high inhibition power at large concentrations.*

Keywords: Frankincense latex, *Staphylococcus aureus*, *Propionibacterium acnes*, Disc diffusion

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Introduction

The frankincense plant which has the species Styrax spp grows on the Asian continent, namely Indonesia, Laos, Vietnam and Thailand. Frankincense plants in Indonesia are found in the regions of North Sumatra, South Sumatra, Java and West Kalimantan. North Sumatra is the largest center for frankincense production in Indonesia [1].

Frankincense is one of the non-wood forest products in the form of resin which can be processed and used for various purposes. Frankincense resin is a dry resin in the form of white or whitish pieces embedded in a clear grayish or reddish-brown mass, has a hard but brittle texture and has a fragrant aroma that is pleasant to inhale [2].

Based on previous research, [3] showed that the active compounds were cinnamic acid (100%) and benzoic acid (45.58%) using a maceration extraction method using ethanol solvent. The active compound cinnamic acid in frankincense resin is usually used as a raw material in the cosmetic and pharmaceutical industries.

Frankincense sap contains flavonoid and tannin compounds which are known to have antibacterial properties that can inhibit the growth of bacteria. Previous research has proven the inhibitory ability of ethanol extract of frankincense leaves on bacteria that cause acne, Propionibacterium acne and Staphylococcus epidermidis [4], and acts as an antibacterial agent against Escherichia coli and Streptococcus mutans [5].

Utilizing frankincense resin is one way to increase production value which can be developed into medicinal plants with high economic value. Several studies have shown the potential of frankincense resin extract as an antibacterial. Based on the description above, research was carried out using the maceration method in making frankincense resin extract using ethanol solvent. The aim of this research is to test the antibacterial activity of ethanol extract of frankincense sap using the disc diffusion method with various extraction concentrations of 1%, 3%, 5%, 10%, 15%, 20%, 25% against the bacteria *Staphylococcus aureus* and *Propionibacterium acnes*.

Methodology

Tools and materials

The tools used in this research were analytical scales, a set of glassware, vacuum, autoclave, petri dishes, oscillating needles, micro pipettes, aluminum foil, rotary evaporator, magnetic stirrer, hotplate, bunchner, maceration bottle, vernier caliper, spatula, stirring rod, paper discs, vials, incubators.

The materials used in this research were Frankincense gum powder measuring 80 mesh from the Parsoburan area, 96% ethanol, Aquades, dragendrof reagent, $FeCl_3$ 5%, concentrated HCl, $FeCl_3$ 1%, nutrient agar (HIMEDIA), DMSO, chloramphenicol (Oxoid), physiological NaCl 0.9%.

Procedure

Making frankincense gum extract

Extract frankincense resin powder using the maceration method. In the maceration method, 80 mesh weighing 250 g is soaked using 96% ethanol solvent with a ratio of 1:2. Extraction was carried out for 3×24 hours at room temperature and remaceration was carried out on days 2 and 3 [6]. Then the entire filtrate is filtered with filter paper using a buncner filter and a vacuum pump. The filtrate is separated and concentrated on a rotary evaporator at the boiling point of the solvent within 4-5 hours [7].

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Identification of Secondary Metabolites

The test solution for phytochemical screening was prepared by dissolving 500 mg of ethanol extract of frankincense sap in 50 mL of 96% ethanol. Flavonoids were tested for their presence using Mg and HCl. [8] Identify flavonoid compounds by adding 5% $FeCl_3$ to the extract. The test will be positive if a blackish green color appears. Test compounds that contain alkaloids, then when tested with Dragendorff's reagent a brown-orange or orange precipitate will form [9]. with the addition of 1%, $FeCl_3$, the test will show a blue or blackish green color indicating the presence of tannin [10]. The saponin test is carried out by adding distilled water, then homogenizing with HCl [11].

Tool Sterilization

Sterilization with dry air usually uses an oven. This tool is used to sterilize glassware, such as Erlenmeyer flaks, petri, test tubes and other glassware. The temperature in dry sterilization is generally 170-180 ^oC for at least 2 hours. Next, use hot steam for materials in liquid form that cannot be sterilized in an oven. The tool used is an Arnold steam sterilizer with a temperature of 100 ^oC for 30 minutes. Sterilization with pressurized hot water steam, the tool used is an autoclave equipped with a safety valve. This tool has a pressure of 2 atm and a temperature of 121^oC for 15 minutes for materials and 20 minutes for tools. This method can kill existing bacteria [12].

Making Media and Cultivating Bacteria

As much as0.46 grams of Nutrient Agar (NA) was dissolved in 20 ml of distilled water (23 g/1000 ml) using an Erlenmeyer flask. After that, homogenize with a stirrer over a water bath until it boils. A total of 5 ml was poured into 3 sterile test tubes each and covered with aluminum foil. The media was sterilized in an autoclave at 121 for 15 minutes, then left at room temperature for ± 30 minutes until the media solidified at a slope of 30. The test bacteria were taken with a sterile tube needle, then planted on the agar medium by scraping. Next, it was incubated in an incubator at temperature 37 for 24 hours. The same treatment was carried out on each type of test bacteria [13].

Preparation of Test Bacterial Suspension

2 doses of test bacteria resulting from rejuvenation were converted into suspension form by dissolving them in 2 mL of physiological NaCl in a sterile test tube. The homogenization process was carried out with the help of a vortex for 15 seconds. After that, the turbidity was compared with 0.5 Mc Farland solution (equivalent to 3x108 CFU/mL).

Antibacterial Activity Test of Frankincense Sap Extract

Disc Diffusion is the method that will be used to examine the antimicrobial activity of frankincense sap extract. The test results are based on measuring the diameter of the bacterial growth inhibition zone (DDH) which forms around the paper disc. First, test solutions are prepared in different concentrations. This research used extract concentrations of 1%, 3%, 5%, 10%, 15%, 20%, and 25%. Sterile agar media was put into sterile petri dishes up to 20 mL and left at room temperature. Then 200 µL of the test bacterial suspension was dropped into the medium and spread evenly. Sterile paper discs with a diameter of 6 mm were dripped with frankincense sap extract with various concentrations and placed in a petri dish containing solid agar media dripped with test bacteria, DMSO (negative control), and chloramphenicol (positive control). Then incubated at

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temperature 37 for 24 hours. After 24 hours, the diameter of the clear partition zone formed was calculated using a caliper [14].

Result and discussion

This research was carried out using a method that is classified as a cold extraction method, namely the maceration method, which does not involve heat during the extraction process and aims to avoid damage to secondary metabolites due to heat. A total of 250 grams of frankincense resin powder measuring 80 mesh was extracted with 500 ml of 96% ethanol.

Ethanol acts as a polar solvent which can attract all the compounds contained in frankincense gum powder. Extraction was carried out 3×24 hours at room temperature and remaceration was carried out on the 2nd and 3rd days by soaking the residue again in 500 ml of 96% ethanol with the aim of extracting compounds that might still remain in the sample powder so that more compounds could be extracted [15].

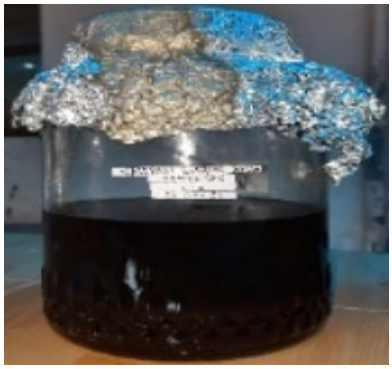

Figure 1. Maceration process of Styrax benzoin

The filtrate is concentrated using a rotary evaporator so that the solvent in the filtrate evaporates/is drawn back to form a thick extract. The thick brownish black extract of frankincense sap was 214 grams with the extract yield calculated by comparing the final weight (the weight of the extract produced) with the initial weight (the weight of the frankincense gum powder used) multiplied by 100% [16]. The yield obtained using maceration extraction:

$$\%\ yield = \frac{extract\ weight}{raw\ material\ weight} \times 100\%$$

$$\%yield = \frac{214\ g}{250\ g}100\%$$

$$\%yield = 85{,}6\%$$

In this study, identification of secondary metabolites was carried out with the aim of identifying the content of a compound contained in the ethanol extract of kemenyan sap originating from the Parsoburan area which can act as an antibacterial. The results of secondary metabolite identification are presented in the table below:

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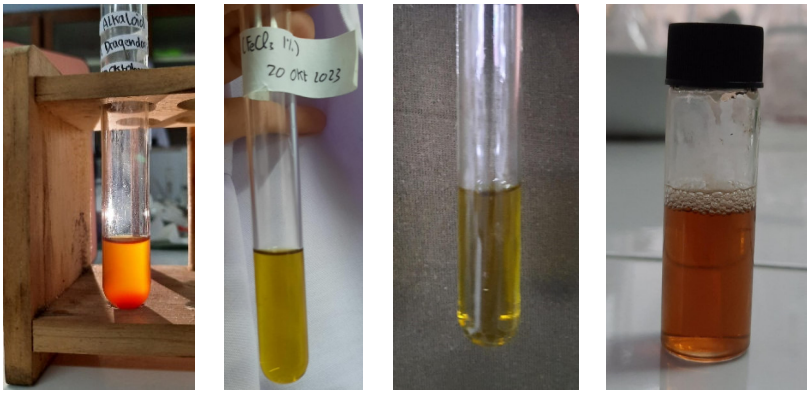
Table 1. Results of identification of secondary metabolites

Peak	Class of compounds	Results	Explanation
1	Alkaloid	+	A red-orange precipitate is formed
2	Flavonoid	+	Produces a blackish green color
3	Tanin	+	Produces a blackish green color
4	Saponin	+	There is foam

Note: (+) contains secondary metabolites and (-) does not contain secondary metabolites



(a) (b) (c) (d)

Figure 2. Results of identification of secondary metabolites in the image: (a) alkaloid test, (b) flavonoid test, (c) tannin test and (d) saponin test.

The existence of secondary metabolites is an important factor through its antibacterial mechanism, where the content of secondary metabolites in the ethanol extract of kemenyan sap is identified to see the content of compounds that can act as antibacterials. The mechanism of action of flavonoids is by causing damage to the permeability of bacterial cell walls and inhibiting bacterial motility. Tannins work by binding protein walls so that the formation of bacterial cell walls is hampered. Saponins have molecules that can attract water or are hydrophilic and molecules that can dissolve fat or lipophilic so they can reduce cell surface tension which ultimately causes the destruction of bacteria. Alkaloids can be used as antibacterial agents because alkaloids can attack cell wall polypeptides, causing cell wall damage in bacteria.

Several previous studies have proven the inhibitory ability of ethanol extract of frankincense leaves on acne-causing bacteria, Propionibacterium acne and Staphylococcus epidermidis, and acting as an antibacterial agent against Escherichia coli and Streptococcus mutans. In this study, the antibacterial activity of ethanol extract of frankincense sap was tested against bacteria found on human skin, Staphylococcus aureus and Propionibacterium acne with several extract concentrations of 1%, 3%, 5%, 10%, 15%, 20%, and 25%. This test was carried out using the disk diffusion method to measure the diameter of the inhibition zone at each concentration of frankincense sap extract.

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Table 2. Results of measuring the diameter of the inhibition zone

Test Sample	Average diameter of zone of inhibition (mm)	
	Staphylococcus aureus	*Propionibacterium acnes*
Positive control	19,81	18,41
Negative control	0	0
1% extract concentration	0	9,52
3% extract concentration	12,69	10,41
5% extract concentration	16	13,46
10% extract concentration	16,50	14,47
15% extract concentration	17,39	15,11
20% extract concentration	18,15	15,87
25% extract concentration	18,53	16,25

The method used in this research is disk diffusion using the Kirby Bauer method, which is to see the antibacterial activity of frankincense sap extract (*Styrax benzoin*). Factors that can influence the size of the inhibition zone are the sensitivity of the organism, pH, type of microbe, antimicrobial materials used such as culture media, agar diffusion speed, and incubation conditions. The antibacterial activity of frankincense sap extract against the bacteria Staphylococcus aureus and Propionibacterium acnes at several extract concentrations of 1%, 3%, 5%, 10%, 15%, 20% and 25% showed that there was a clear zone growing around the paper disc.

The higher the concentration used in this research, the larger the clear zone that forms. Conversely, the smaller the concentration used, the lower the clear zone that forms around the paper discs that have been dripped with various concentrations. This is because there are high levels of active ingredients in the frankincense sap extract which makes the clear zone formed around the disc paper higher.

Conclusion

The results of the research showed that the extract yield was 85.6% with the identification of secondary metabolites in the kemenyan sap extract containing active compounds in the form of alkaloids, flavonoids, tannins and saponins which act as inhibitors of bacterial growth and have antibacterial activity against the bacteria Staphylococcus aureus and Propionibacterium acnes at an extract concentration of 1% , 3%, 5%, 10%, 15%, 20%, and 25% with small inhibitory power at low concentrations and large inhibitory power at high concentrations.

Acknowledgments

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Upgrading Bio-Oil Through Esterification-HDO Process: Optimization Of Temperature And Mass Ratio Of Fe-Co Mixed Metal Oxide Catalyst Supported By Mordenite

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Abstract. *Improving the quality of bio-oil for use as an alternative fuel still has various challenges. The esterification and hydrodeoxygenation (HDO) processes with Fe-Co mixed-metal oxide catalyst supported by mordenite are known to have good activity and selectivity in upgrading bio-oil. In this study, optimization of the HDO process was carried out by varying the temperature (250, 275, 300, 325, 350 ℃) and the mass ratio of the catalyst (2.5; 3; 3.5 wt%) used. The results obtained show that at 325 ℃ and catalyst mass ratio of 3.5 wt% produces the most optimum yield of liquid product. In addition, there was an increase in the physicochemical properties of bio-oil including an increase in higher heating value (HHV), reduced water content, and decreased total acid number and oxygen component when compared to raw bio-oil.*

Keywords: Optimization, bio-oil, Fe_2O_3-CoO/Mor, esterification, hydrodeoxygenation

1. Introduction

Liquid products resulting from pyrolysis of lignocellulosic biomass such as palm fronds are known to have potential as alternative fuels. Intermediate pyrolysis is a method that provides flexibility in converting palm frond biomass into liquid products (Bio-oil). The use of bio-oil as a fuel still has various challenges, this is related to its instability due to the high oxygenate component, besides various other properties such as acidity, water content, high calorific value, and viscosity make bio-oil need further consideration for its use as a transportation fuel. Various studies have been developed to overcome these problems. Hydrodeoxygenation (HDO) is a preferred method to improve the quality of bio-oil by reducing the oxygen component contained therein. In addition, the combination with the esterification process has the advantage of converting the acidic components in bio-oil into a more stable ester form. Therefore, by combining the two upgrading methods (esterification-hydrodeoxygenation), it is possible to obtain bio-oil with more optimal physicochemical properties [1].

The catalyst has an important role in the HDO reaction. Many catalyst modifications have been made in the HDO bio-oil process, the catalytic process with a combination of metal and support catalysts is known to have superior activity and stability [2]. The synergy between the metal and the carrier is an important factor during the HDO process. Mordenite is a zeolite that can be used as a carrier due to its high thermal stability and specific surface area [3]. Deactivation of the catalyst is a problem that can be encountered during the catalytic process, therefore the presence of metal in the carrier has a positive effect by hydrogenating the coke precursor in mordenite. Heterogeneous catalysts based on cobalt metal can be used as a promising alternative. Among several transition metal oxides, cobalt oxide catalysts have been shown to have good catalytic performance in several reactions including the oxidation of hydrocarbon-bromination [4], decomposition of N_2O [5], epoxidation of alkenes [6], and formaldehyde elimination [7]. However, the catalytic activity, product selectivity, and stability of the cobalt oxide catalyst need to be further improved by increasing the active site of the catalyst. Metal iron (Fe) is a transition group element that provides d orbitals that are not filled with electrons so that it can increase the total acidity of the catalyst. The use of metal oxides such as Co and Fe is known to have various

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advantages, such as the presence of Fe metals oxide can catalyze the hydrogenation of the C=O bond and inhibit the breaking of the C-C bond during the HDO process. Iron-bearing in the catalyst played an important role by increasing the interaction between Co oxide and mordenite, which stabilized Fe_2O_3-CoO/Mor catalyst during the bio-oil HDO reaction. The better the interaction between Co oxide and mordenite, the better the adsorption of oxygenated compounds from raw bio-oil by Fe_2O_3-CoO/Mor catalyst [1,8]. In addition to the use of catalysts, several parameters can also affect the HDO process, including hydrogen gas pressure, temperature, reaction time, and the mass ratio of the catalyst used [9].

Temperature is one of the most important parameters in HDO. Temperature is related to the activation of the acid catalyst sites and the energy dissociation of the reactants. Wang et al. [10] reported that higher temperatures increased the proportion of aromatic hydrocarbons. Optimal conditions provide selectivity of 49% aromatics (benzene, toluene, and xylene) using a 5% Ni_2P/HZSM-5 catalyst. In addition, the mass of the catalyst will be related to the number of active sites available during the reaction. Heterogeneous catalysts have the advantage of preventing polymerization during HDO. Moreover, heterogeneous catalysts can adjust their acid density and can promote the synergistic role of metal sites and support the increase of oxygen vacancies in the catalyst, which ultimately accelerates the upgrading process.

In previous studies, the characteristics of the Mordenite catalyst and after metal embedding (Fe_2O_3-CoO/Mor) were studied which showed better selectivity and activity in the Esterification-Hydrodeoxygenation of bio-oil from palm fronds. Therefore, in this study optimization of conditions will be carried out by varying HDO parameters using a Fe_2O_3-CoO/Mor catalyst to improve the quality of the bio-oil that has been produced.

2. Method

2. 1 Material

Bio-oil is obtained from the pyrolysis of palm fronds. The materials used in this study were synthetic mordenite type zeolite (HSZ-640HOA, Tosoh Corporation Japan), $FeCl_3 \cdot 6H_2O$ (E. Merck), $Co(NO_3)_2 \cdot 6H_2O$ (E. Merck), deionized water, ethanol p.a (E. Merck), H_2SO_4 (E. Merck), KOH (E. Merck), oxygen gas, and nitrogen gas (PT.Aneka Gas Medan).

2.2 Catalyst Preparation

The preparation of the Fe_2O_3-CoO/Mor catalyst was carried out using a wet impregnation process. Mordenite was first activated through a calcination process at 500°C by flowing with N_2 gas for 2 h, then impregnated with metal Co (0.5%) which had been dissolved in deionized water into 100 g of mordenite. The impregnation process was carried out using the reflux method while stirring for 5 h at 80 °C. After finishing the mixture was dried in the oven, and then Fe metal (0.5%) into the Co/Mor catalyst with the same steps as before. The final stage of the Fe-Co/Mor catalyst obtained was oxidized for 2 h at 500°C with oxygen gas flowing through it.

2.3 Optimization of the esterification-hydrodeoxygenation process

The esterification procedure for upgrading bio-oil follows [11], bio-oil and ethanol are mixed in a ratio of 1:1 (w/w) into the flask, and H_2SO_4 is added as a catalyst as much as 1% of the sample weight. The mixture was refluxed while stirring at 60 °C for 2 h. The hydrodeoxygenation process follows [12], the mass ratio of the catalyst to the esterified bio-oil is 2% (wt%). The HDO process was carried out in a fixed-bed system reactor by flowing H_2 gas for 2 h and varying temperatures (250, 275, 300, 325, and 350 °C). The optimum temperature with the highest yield liquid product

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was carried out by varying the mass ratio of the catalyst (2.5, 3, 3.5 wt%) in the HDO process for further analysis related to its physicochemical properties.

2.4 Characterization of Bio-oil

Bio-oil was characterized by a comparison of its physicochemical properties before and after the HDO-esterification process using a catalyst. The characterization includes elemental analysis (C,H,N,O) using CHN Analyzer LECO-CHN 628, water content using Metrohm 870 KF Titrano Plus, determining acid number using titrimetry method, HHV using formula Sheng and Azvedo, Gas Chromatography-Mass Spectrometry (GC -MS QP2010 Plus Shimadzu brand) to determine the compounds contained in liquid products, density analysis using the gravimetric method, and viscosity.

3. Result and Discussion

3.1 Effect of temperature on hydrodeoxygenation

Pre-treatment of bio-oil by esterification is expected to convert acidic compounds into ester compounds which are more stable and followed by an increase in the physicochemical properties of bio-oil such as reducing water content, reducing acidity, increasing volatility, and increasing heating value. The esterified bio-oil is continued in the hydrodeoxygenation reaction with a bimetallic Fe_2O_3-CoO/Mor catalyst of 2% (wt%) with temperature variations of 250, 275, 300, 325, and 350 °C to obtain liquid product yields at the most optimal temperature.

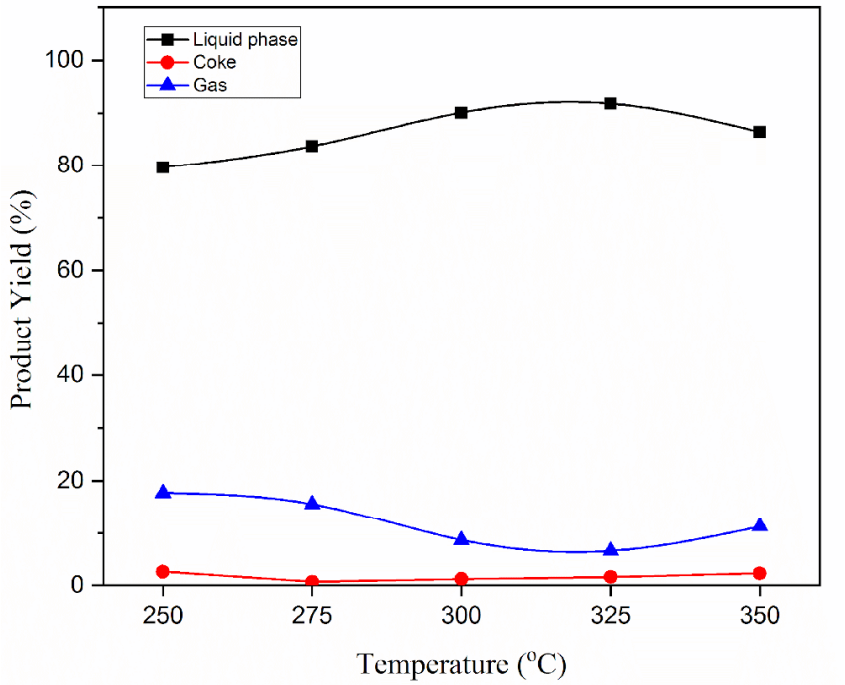

Figure 1. The effect of temperature on the product distribution of HDO results using Fe_2O_3-CoO/Mor catalyst.

Based on Fig. 1, there was an increase in liquid product from 250-325 °C and decreased at 350 °C. The optimum conditions were obtained at 325 °C with the highest yield of 91.81%. The most coke formation was obtained at 250 °C of 2.63 % and tended to decrease at 275 °C and then

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increase again to 350 °C. The difference in product distribution obtained from various temperatures shows that temperature variations have an impact on the distribution of HDO products, this is as revealed by Remon et al. [13] it is known that the formation of liquid products is more efficient in the range of 270-330 °C, especially in converting guaiacol. In the HDO product distribution data, the highest gas yield was obtained at a temperature of 250 °C, this indicates that this temperature supports the occurrence of gasification or hydrocracking reactions from bio-oil which converts organic compounds into gaseous products [14]. The effect of temperature variation on the distribution of the resulting HDO product shows that the optimum conditions are obtained at 325 °C, the maximum yield of liquid product, and fewer coke constituents are obtained. From the temperature variation data, the optimum conditions obtained were then carried out by varying the mass ratio of the catalyst.

3.2 Effect of catalyst mass ratio on Hydrodeoxygenation

The catalytic activity of a zeolite is closely related to the presence of active sites on the zeolite. Therefore, in this study, the effect of adding the mass of the catalyst used during the HDO process was observed. The resulting product distribution is summarized in Fig. 2.

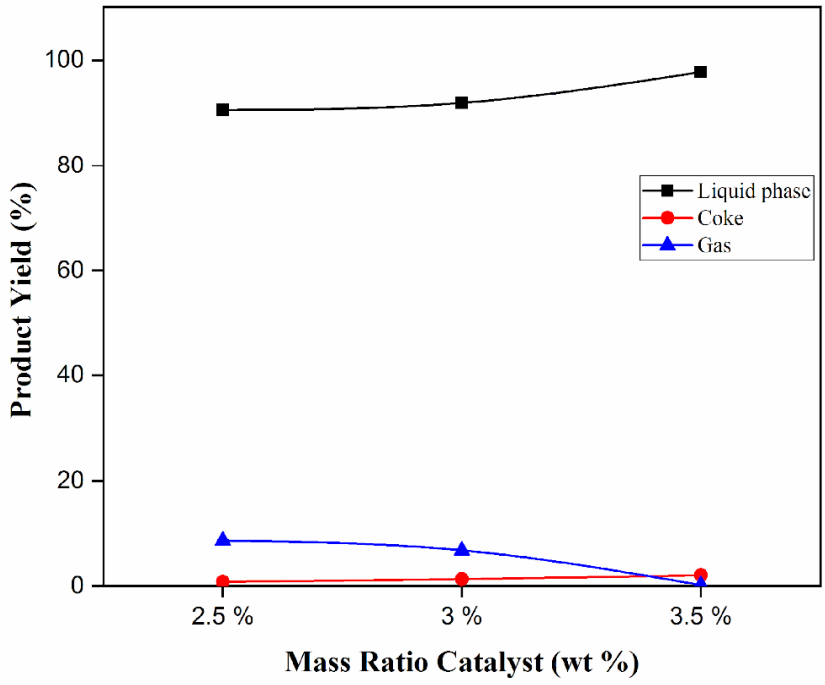

Figure 2. The effect of the mass ratio of Fe_2O_3-CoO/Mor catalyst on the distribution of HDO products at an optimum temperature of 325°C

In Fig. 2, the catalyst loading ratio of 3.5% shows the most optimal liquid product formation of 97.78%, and gas formation of at least 0.19%, while the coke formed is the largest among the others (2.03%). This is inversely proportional to the catalyst ratio of 2.5% which shows the lowest liquid product of 90.61%, but the highest gas formation (8.58%) and the least coke produced (0.81%). Coke in HDO can be formed due to polymerization during the HDO process [15]. Coke is derived from compounds that contribute to bio-oil instability, such as carboxylic acids, ketones, aldehydes, and especially phenols and furans. Oxygenated compounds with two oxygen atoms in

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the benzene ring tend to polymerize and condense more [16]. Alkyl phenols can form coke even at low temperatures [17].

3.3 Physicochemical Properties

Analysis of the physicochemical properties of the HDO liquid product included elemental content, calorific value, viscosity, acid number, and analysis of the compound content by GC-MS. The physicochemical properties of the initial bio-oil, and upgraded bio-oil using the bimetallic Fe_2O_3-CoO/Mor catalyst are summarized in Table 1. The data obtained shows that pretreatment with an esterification process and continued hydrodeoxygenation has been shown to improve the physicochemical properties of bio-oil.

Table 1. Physicochemical properties of raw bio-oil and HDO Fe_2O_3-CoO/Mor 3.5 %

Properties	Raw bio-oil	Fe_2O_3-CoO/Mor
Water content (%)	88.87	55.25
Density (g/cm^3)	0.92	0.84
Viscosity (cP)	0.71	0.79
TAN (mg NaOH/g oil)	61.41	16.57

There was a decrease in the total acid number (TAN) which was 61.41 mg NaOH/g oil to 16.57 mg NaOH/g oil, this indicates that esterification pretreatment can reduce the carboxylic acid components in raw bio-oil into more stable ester compounds. This shows that the organic acid compounds contained in the bio-oil have been reduced. Reducing the acid content provides better stability for bio-oil [18]. In addition to reducing the acidity, the addition of polar solvents such as ethanol in the esterification process also affects reducing density and increasing the heating value of bio-oil [11]. The decrease in density that occurs in upgraded bio-oil shows that macromolecular compounds in raw bio-oil can convert catalysts into monomers or low molecular compounds in upgraded bio-oil [19]. The water content in the upgraded bio-oil decreased to 55.25% through the HDO-esterification process using a 3.5% (wt %) Fe_2O_3-CoO/Mor catalyst, this decreased water content was in line with the reduced oxygen content from elemental analysis data (Table 2).

Table 2. Elemental analysis C,H,N,O

Properties	Raw bio-oil	Fe_2O_3-CoO/Mor
Elemental analysis (wt %)		
C	7.59	22.59
H	10.27	11.03
N	0.19	0.07
O[a]	81.95	66.31
H/C	16.17	5.82
O/C	8.12	2.20
DOD (%)	-	72.90
HHV (MJ/kg)[b]	10.82	15.56

[a]calculated based on the difference.

[b] calorific value is calculated based on the following formula: HHV (MJ/ kg) = -1.3675 + (0.3137 C) + (0.7009 H) + (0.0318 O)

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The HDO process using Fe_2O_3-CoO/Mor 3.5 % (wt %) catalyst succeeded in reducing the oxygen content present in the bio-oil from 81.95 wt% to 66.31 wt%, increasing the HHV value and a decrease in the acidity of the bio-oil. The HHV value after the upgrading process increased from 10.82 MJ/kg to 15.56 MJ/kg. The deoxygenation reaction is more dominant in the HDO process with Fe_2O_3-CoO/Mor 3.5 % (wt %) catalyst, this was driven by a decrease in the O/C ratio from 8.12 to 2.20 and the degree of deoxygenation (DOD) was 72.90%. A decrease in oxygen content can occur through deoxygenation, decarbonization and decarboxylation reactions [20].

The components of the compounds contained in raw bio-oil and the results of HDO-esterification with a 3.5% Fe_2O_3-CoO/Mor catalyst were analyzed using GC-MS with chromatogram in Fig. 3 and the tabulation of the compounds contained are summarized in Table 6. It is known that the compounds contained in raw bio-oil resulting from the pyrolysis of palm frond biomass are dominated by the phenol group which is a lignin derivative from the conversion of lignocellulosic in palm fronds. The formation of phenol-derived compounds is more dominantly related to temperature during the pyrolysis process temperature of 300-500 ℃ [21]. The decrease in the phenol component after HDO may occur because it undergoes alkylation to form cresol. It can be seen that the % area of cresols increases after the HDO process. In addition, cresol can also be formed from catechol through a direct deoxygenation reaction [22]. After the HDO process, the 1-pentene-3-one component is formed which is possible from the deoxygenation reaction of the compound propanoic acid, ethyl ester. The presence of Co in the Fe_2O_3-CoO/Mor catalyst used during HDO is known to promote hydrogenolysis and hydrogenation reactions in HDO bio-oil, as well as increasing the breaking of C-O bonds directly thereby encouraging the hydrodeoxygenation reaction of phenolic compounds [23].

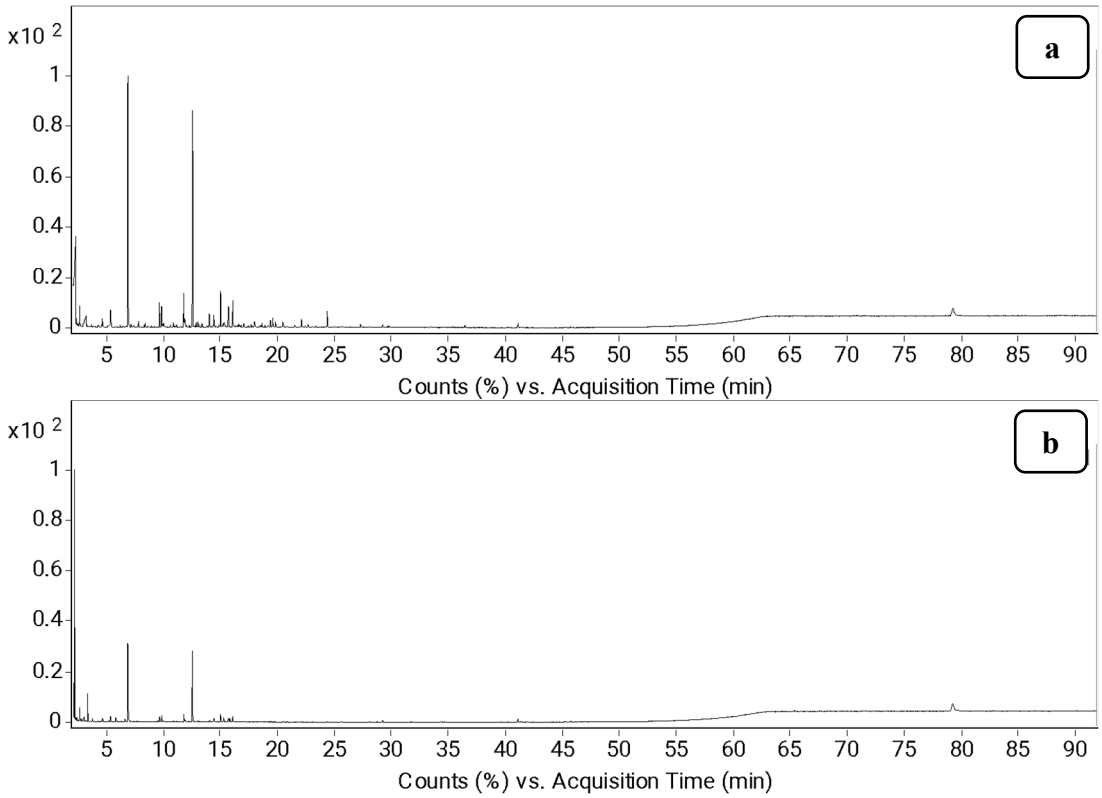

Figure 3. Chromatogram of a) raw bio-oil, and b) HDO with Fe_2O_3-CoO/Mor catalyst

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Table 3. Compound Components of raw bio-oil and HDO Fe_2O_3-CoO/Mor

No.	Compound	Amount (% area)	
		Raw Bio-oil	Fe_2O_3-CoO/Mor
1.	n-Hexadecanoic acid	0.41	0.77
2.	Propanoic acid, ethyl ester	-	3.97
3.	2-Furancarboxaldehyde, 5-methyl-	2.45	1.43
4.	3-Furaldehyde	-	16.41
5.	Ethanone, 1-(2-furanyl)	1.46	1.19
6.	2-Cyclopenten-1-one, 2-methyl	2.08	1.20
7.	2-Cyclopenten-1-one, 2,3-dimethyl	1.51	0.75
8.	2-Cyclopenten-1-one,3-hydroxy-2-methyl-	1.10	-
9.	1,3-Cyclopentanedione, 2,4-dimethyl	0.28	-
10.	Syringylacetone	0.22	-
11.	Phenol	18.27	12.86
12.	Phenol, 2- methyl	2.48	1.67
13.	Phenol, 3-methyl	2.41	-
14.	Phenol, 2-methoxy	2.05	1.19
15.	Phenol, 2,6-dimethoxy	1.37	-
16.	Phenol, 3,5-dimethyl	1.04	-
17.	2,4-Di-tert-butyl-phenol	0.24	0.44
18.	Cresol	0.55	1.22
19.	Catechol	0.84	-
20.	3,5-Dimethoxy-4-hydroxytoluene	0.27	-
21.	1,3-Dimethyl-1-cyclohexene	0.27	-
22.	1H-Pyrazole, 1,5-dimethyl	19.82	-
23.	1-Penten-3-one	-	1.28

Conclusion

Based on data obtained from upgrading bio-oil from pyrolysis of palm fronds by esterification-hydrodeoxygenation process using Fe_2O_3-CoO/Mor catalyst, it was concluded that hydrodeoxygenation operating conditions with the optimum yield of liquid products were obtained at a temperature of 325 ℃ with a catalyst mass ratio of 3.5 %. The upgrading process is proven to improve the physicochemical properties of bio-oil by decreasing the density, water content, and total acid number, and increasing the HHV value. The oxygen contained also decreased, with the degree of deoxygenation reaching 72.90%. After the HDO process, new compounds such as 1-Penten-3-one were also detected

Acknowledgments

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Synthesis of Quercetin-Chitosan (Qt-Cs) Nanoparticles as Flavonoids Derivatives of Coffee Leaves Parasite (*Loranthus parasiticus* (L.) Merr) Isolates

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Abstract. *Coffee parasite (Loranthus parasiticus (L.) Merr) is a useful plant that is widely used as traditional medicine. This particular plant is usually found and identified as a parasite on coffee tree and thus known as coffee parasite leaves. One of the secondary metabolites in coffee parasite leaves that potential as antioxidant is quercetin. The use of quercetin as an active drug compound that is ready for use is still very limited due to the solubility and dissolution rate problems of this compound in water. For this reason, it is necessary to synthesize nanoparticles to increase their solubility and dissolution rate. Chitosan-quercetin nanoparticles have been synthesized by ionic gelation method using quercetin isolated from coffee parasite leaves as an anticancer agent. The process of making chitosan nanoparticles was carried out by adding NaTPP to the Chitosan-Quercetin (QT-CS) solution with various comparisons. Physical properties including PSA analysis as well as acidity and antibacterial activity tests were carried out to determine the nature of all five different formula. The results showed that the smallest particle size (44.54 nm) was produced using NaTPP: QT-CS (1:30). The results of colloidal nanoparticles have a viscosity of 15.5190 mPa.s, a density of 1.0404 kg / L, have a bright yellow colloidal color and have an acidic pH with refractive index of >1.070. QT-CS nanoparticles have no potential as antibacterial agents for Enterococcus faecalis and Proteus vulgaris bacteria.*

Keywords: *Loranthus parasiticus,* chitosan, nanoparticle, solubility

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Introduction

One of the medicinal plants that are considered parasite but rich in benefits is the coffee parasite plant. Coffee plant parasite (*Loranthus parasiticus* (L) Merr is widely used as a traditional medicine as anti-cancer, anti-allergic, anti-tumor, cold medicine, cough, diarrhea, wounds, rheumatism, and other degenerative diseases [1].[2]. One of the secondary metabolites contained in coffee leaves is quercetin [3], [4]. Currently, the use of quercetin as an active drug compound that is ready for use is still very little due to the problem of solubility and dissolution rate of this compound in water [5], [6]. For this reason, efforts need to be made to increase the dissolution rate by synthesizing it into nanoparticle size.

Nanoparticles are a promising method for drug delivery systems from extracts of secondary metabolites from plants, especially on leaves that have a high flavonoid content [7]–[9]. Nanoparticles were originally made using non-biodegradable polymers, but were replaced by biodegradable polymers[10][11][12]. Nanoparticles from biodegradable polymers are used as drug delivery systems [11] , which have beneficial properties such as easy degradability in the body, modifications in the body, and functions that can be adjusted as needed so as to regulate the pharmacokinetic stability properties of drugs [13]. One of the biodegradable natural polymers is chitosan.

Chitosan conjugate - quercetin is synthesized by an indirect conjugation method involving two steps. Modifying with anhydrous acetic acid provides an active group of quercetin molecules (COOe) that allows attachment of terminal groups in the main frame of chitosan. The main skeletal chains of chitosan polymers together create a continuous molecular chain with quercetin. Carbodiimide reaction between chitosan amino group and carboxyl group of quercetin [8]. In this research, the development of nano-sized medicinal active ingredients derived from natural ingredients in this case coffee leaves. It is expected that the use of quercetin from coffee leaf extract processed using nanotechnology will provide better stability. In addition, antibacterial tests were also carried out from the results of the synthesis of these nanoparticles,

Research Methods

Extraction and Separation

Coffee leaves were extracted by maceration using methanol solvent p.a carried out three times. The maceration results are then evaporated solvent and separated the secondary metabolite content by dissolving the solvent N-Hexane, Ethyl Acetate, and Ethanol. The separation process is carried out using thin layer chromatography and liquid vacuum chromatography, so that secondary metabolite compounds have been separated in various solvent fractions. The isolation results were tested by thin-layer chromatography and compared the Rf value with pure quercetin. Fractions that have the same Rf value, indicated that there is quercetin content in it.

Chitosan – Quercetin Nanoparticle Synthesis (QTCS)

The synthesis of QT-CS nanoparticles is carried out by ionic gelation method. Chitosan in this case is intended as a charge polymer on the ammonium group that is positive and can form ionic interactions. NaTPP 1% as a solution is added to avoid the formation of aggregates and as a stabilizer of nanoparticles formed, besides the addition of NaTPP aims as a *crosslinker* that is able to stabilize the remaining positive charge. The formation of chitosan – quercetin nanoparticles can be qualitatively seen by changing the color of the solution to become more

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turbid and produce colloids.

The synthesis process begins by dissolving 1 gram of chitosan using acetic acid solvent then mixing it with 1 gram of quercetin and adding 1% NaTPP solution and in a stirrer at a speed of 2800 rpm for 30 minutes at room temperature. The colloidal results of QTCS nanoparticles were then characterized by physical properties using PSA (Particle Size Analyzer) instruments. The results of colloidal nanoparticles were also tested for bioactivity against *Proteus vulgaris* and *Enterococcus faecalis* bacteria.

QT-CS Nanoparticle Antibacterial Activity Test

1. Preparation and Rejuvenation of Test Bacteria

The antibacterial activity was tested using *Enterococcus faecalis* as gram-positive bacteria and *Proteus vulgaris* as gram-negative bacteria. The positive control used is chloramphenicol and DMSO as negative control because DMSO is a neutral compound that has no effect on bacterial growth.

The solid media used is MHA media (Muller Hinton Agar) which is made by dissolving 15.2 grams of MHA powder into 400 mL of distilled water then heated and sterilized using an autoclave at 121 °C for 15 minutes and poured into a petri dish as much as ±20 mL. While the liquid media used is MHB media (Muller Hinton Broth) which is made by dissolving 5.25 grams of MHB powder into 250 mL of distilled water then heated and sterilized using an autoclave at 121°C for 15 minutes.

Single colonies grown on the dish medium were taken with an ose needle, inoculated into MHA solid media in a zigzag manner. This work is carried out aseptically close to the bunsen burner. Petri dishes are then wrapped in aluminum foil, incubated in an incubator at 37°C for 24 hours. A zig zag pattern can be seen on the agar media. This indicates that the bacteria are still actively multiplying and ready to be used for testing [14], [15].

2. Bacterial suspension test and measurement of absorbance value

Rejuvenated *Enterococcus faecalis* and *Proteus vulgaris* bacteria were taken 1 ose each, put in 5 ml of MHB (Muller Hinton Broth) media and then homogenized using vortex. The suspension then incubated at 37°C for 24 hours. After 24 hours, the bacteria culture in the liquid media were suspended by taking a drop and added with 0.9% NaCl diluent and compared turbidity with MC Farland. After seeing almost similar turbidity, further testing was carried out with a Uv-Vis Spectrometer at wavelength 600 nm to ensure turbidity.

If the absorbance value of the test bacterial suspension is greater, the addition of 0.9% NaCl is added so that the absorbance value of the test suspension is the same as the Mc Farland standard solution with an Optical Density (OD) value of 0.08 – 0.1[16]. If the suspension of both bacteria has an OD value lower than the set range, it is necessary to add another drop of bacteria in the liquid medium.

Both *Proteus vulgaris* and *Enterococcus faecalis* are mesophilic bacteria that can grow at temperatures of 20-45 ° C. For this reason, it is necessary to measure the absorbance in a cold state and carry it in a container containing ice cubes to avoid an increase in absorbance value caused by bacterial growth. It is also intended that the bacteria in the suspension preparation are still alive and survive when the bacteria are measured for absorbance and when mixed into the growth medium. After obtaining an absorbance value that is close, the bacterial suspension can

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be used as a bacterial preparation for the Minimum Bacteriocidal Concentration (MBC) test and the Inhibition Zone.

3. Determination of Inhibitory Zone Diameter by Disc Diffusion Test Method

Disc diffusion test or disc diffusion test is one method that can be done to test antibacterial effectiveness, which is done by measuring the diameter of the clear zone, where the clear zone that appears is an indicatior of a positive response to inhibit bacterial growth by an antibacterial compound.

Mueller Hinton Agar (MHA) media is the media used in this study as a bacterial growth medium. MHA media is dripped with a bacterial suspension with a known OD value of 100 µL, and flattened using an L speader, after which the disc is placed on the cup that has been made and dripped with a test solution of 20 µL. Disc paper that has been dripped with nanoparticle solution on MHA media is incubated in an incubator for 24 hours at a temperature of 37 °C. The results of the disc diffusion test with the first group experimental concentration series with low concentrations are 10,000 ppm, 8,000 ppm, 4,000 ppm, 2,000 ppm, 1000 ppm, 500 ppm, 250 ppm, 125 ppm. As well as a repeat of the second group trial with higher concentrations of 100%, 80%, 70%, 60%, 50%, 40%, 20%, and 10% as well as a positive control of chloramphenicol disc 30 mg and a negative control of DMSO solvent.

4. Determination of Minimum Bactericidal Concentration (MBC) by Quantitative Liquid Dilution method using Uv-Vis spectrophotometry

To 10 test tubes are added 4 mL of MHB media and 2 mL of test solution. This test is carried out by stratified dilution technique using test tubes starting from 50% concentration to 0.1% concentration. Furthermore, a suspension of test bacteria that has known Optical Density values of 2 mL is added then in the vortex and checked the absorbance value at a wavelength of 600 nm. The same was done on 2 test tubes of positive control of chloramphenicol 500 ppm and negative control. After obtaining the absorbance value, the test tube is then closed and incubated for 24 hours at 37 ° C. After 24 hours, the test tube was put in the vortex and then measured the absorbance value at the same wavelength.

5. Determination of Minimum Bactericidal Concentration (MBC) by Solid Dilution method

The determination of the KBM (Minimum Bactericidal Rate) value in this study was carried out using a test solution with 12 concentration series taken from the qualitative MBC determination test with microplate 96 for each bacterium. The test solution taken is the last 4 holes at concentrations of 100%, 90%, 80%, and 70%. The solution is dripped on solid media clean from bacteria as much as 5 µL and made a zig zag pattern, then stored in an incubator for 24 hours at a temperature of 37 ° C.

Results and Discussion

Extraction and Separation

The results of extraction and evaporation obtained a thick green extract of 50.67 grams. The yield of the extract is calculated based on the ratio of the final weight (weight of the extract produced) to the initial weight (weight of the fine sample used) multiplied by 100%. In this case, the yield presentation of coffee leaf plant extract (*Loranthus parasiticus* L. Merr.) obtained was 5.067%. The results of identification through TLC on several selected fractions showed the presence of two stain spots on one of the fractions indicating that the compound was not

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completely pure. However, some other fractions have shown a single spot of stain so that one of these fractions is chosen.

The suspected quercetin compound is at an Rf value of 0.825 after being compared with the quercetin standard with an Rf value of 0.850 with the use of n-hexane eluent: ethyl acetate (7: 3). This is evidenced by the TLC test by comparing with quercetin positive controls. It is this fraction that contains positive quercetin and is ready to be synthesized into nanoparticles.

Chitosan – Quercetin Nanoparticle Synthesis (QTCS)

The initial synthesis experiment used a concentration ratio (v/v%) of NaTPP: QTCS (1: 15) and NaTPP: QTCS (15: 1). The results of both have very different particle sizes. From the results of particle size testing using the ANALYSETTE 22 Nanotec Laser Particle Sizer *instrument* at a ratio of 1: 15 has a particle size of 0.11342 µm while at a ratio of 15: 1 has a particle size of 15.35573 µm.

Furthermore, synthesis is carried out by synthesis carried out with variations in QT-CS concentrations by making NaTPP concentrations still obtained results in table 1 and visualized through graphs in **Figure 1**.

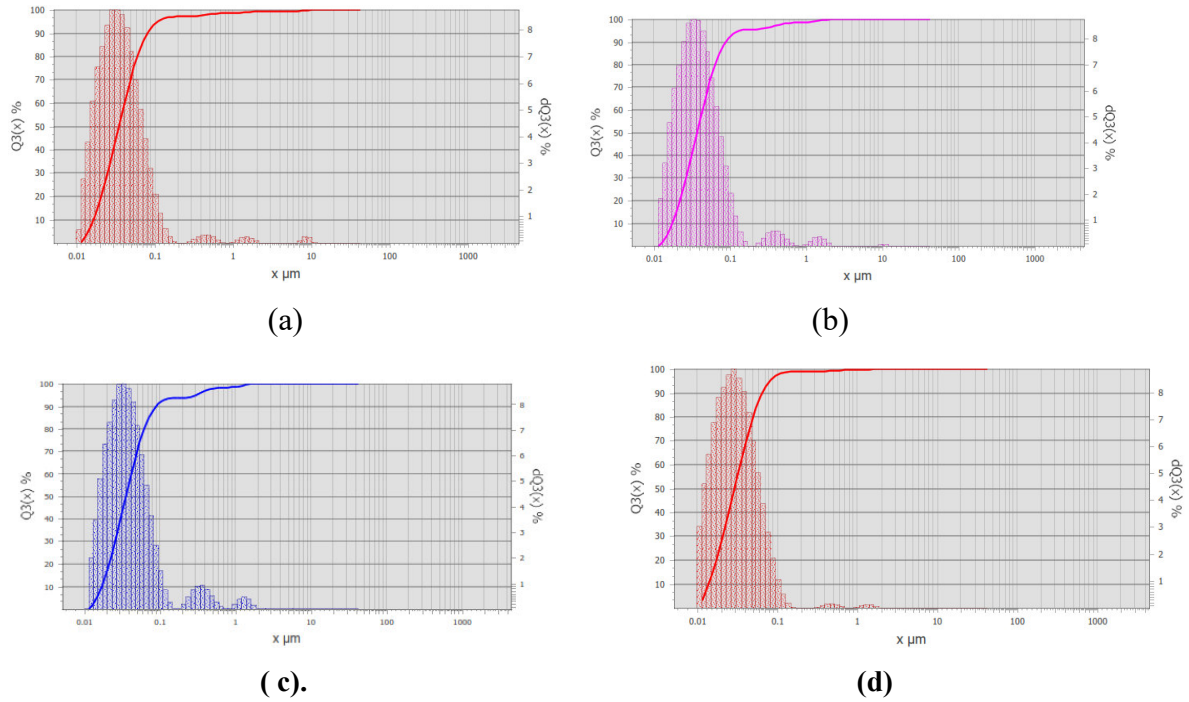

Figure 1. PSA Analysis Results of NaTPP concentration variation:QT-CS (v/v %) a) 1:15 b) 1:20 c) 1:25 d) 1:30.

Table 1. QT-CS Nanoparticle PSA test results

Concentration Variation (v/v %)	Particle size (nm)
NaTPP : QT-CS (1 : 5)	194.72
NaTPP : QT-CS (1: 10)	176.7
NaTPP : QT-CS (1 : 15)	113.42
NaTPP : QT-CS (1: 20)	82.58
NaTPP : QT-CS (1 : 25)	75.88
NaTPP : QT-CS (1: 30)	44.54

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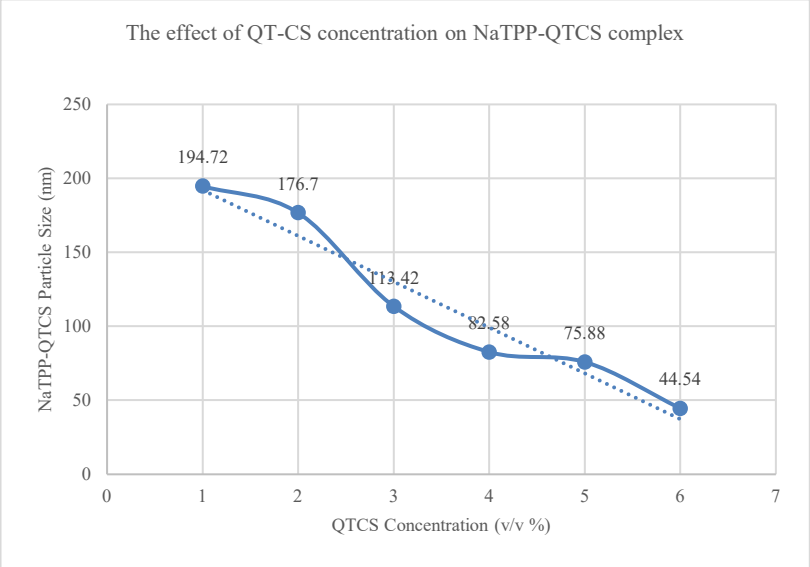

Figure 2 Graph of particle size against solution concentration

From these data, it can be interpreted that at a fixed NaTPP concentration, the higher the QT-CS concentration used, the smaller the size of the nanoparticle suspension produced. This can be caused by the cross-linking between chitosan and NaTPP that has not been controlled if the percentage of NaTPP concentration is greater because it has a tendency to continue to form larger aggregates. The formation of aggregates is characterized by increased properties of density and elasticity of chitosan-quercetin solutions.

The synthesis results through the ionic gelation method show a thick yellow color that thickens like a colloid. The yellow color formed due to the presence of quercetin is bright yellow. The results of the colloidal nanoparticles formed are then tested for their physical and chemical properties. The physical and chemical properties of QT-CS nanoparticles are shown in **Table 2**.

Table 2. Physical and Chemical Properties of QT-CS Nanoparticles

Viscosity	15.5190 mPa.s
Density	1.0404 kg/L
Color	Bright yellow
Odor	Acidic
Refraction Index	>1.070

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QT-CS Nanoparticle Antibacterial Activity Test

1. Determination of Inhibitory Zone Diameter by Disc Diffusion Test Method

The results of the disc diffusion test with the first group experimental concentration series with low concentrations are 10,000 ppm, 8,000 ppm, 4,000 ppm, 2,000 ppm, 1000 ppm, 500 ppm, 250 ppm, 125 ppm. As well as repeats of the second group experiment with higher concentrations of 100%, 80%, 70%, 60%, 50%, 40%, 20%, and 10% as well as positive control and negative control are presented in figure 4.15.

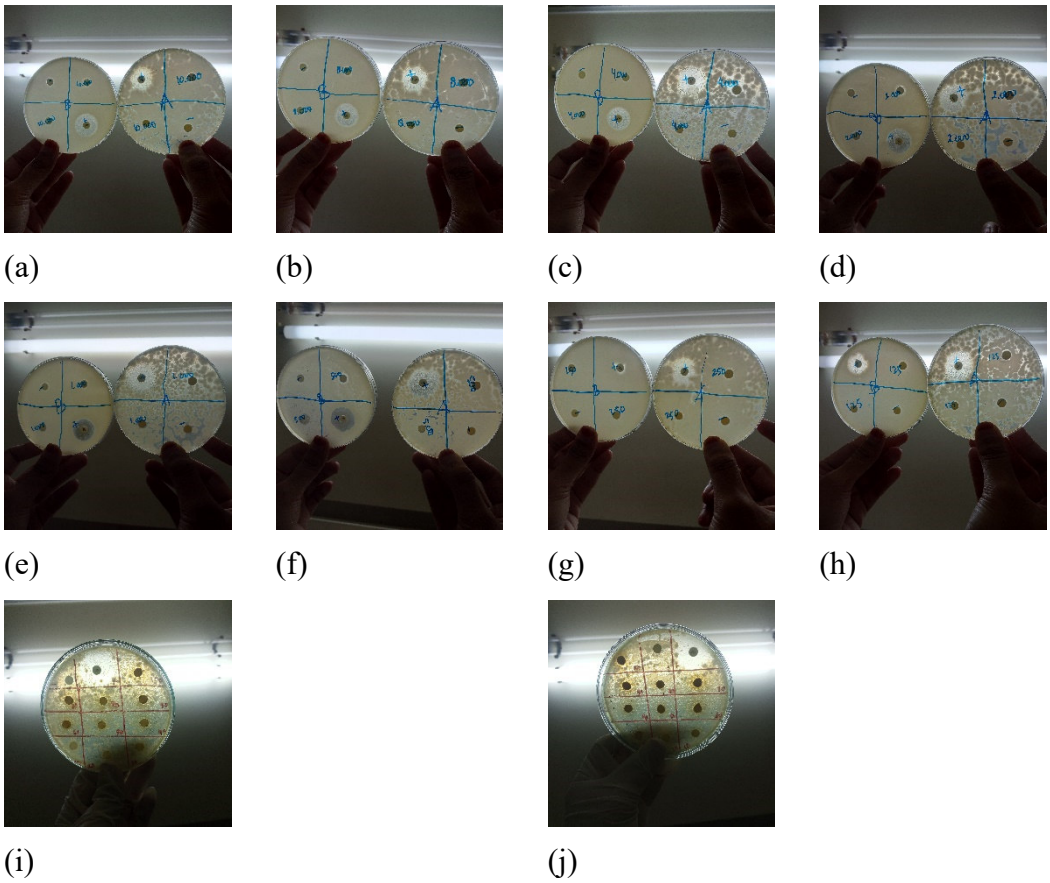

Figure 3. Test results of Inhibitory Zones of *Enterococcus faecalis* and *Proteus vulgaris* with concentrations of (a) 10,000 ppm, (b) 8,000 ppm, (c) 4,000 ppm, (d) 2,000 ppm, (e) 1,000 ppm, (f) 500 ppm, (g) 250 ppm, (h) 125 ppm, (i) concentration of 100-10% bacteria *Enterococcus faecalis*, (j) Concentration of 100-10% bacteria *Proteus vulgaris*

From the test results with the disc diffusion test method carried out, it can be seen that each QT-CS Nanoparticle sample solution with a low concentration series in experiment 1 and high concentration in experiment 2 cannot produce a clear zone in the area around the disc. With the increasing concentration of QT-CS nanoparticles, it does not have any effect on the growth power of bacteria. Therefore, QT-CS nanoparticle sample solution with the concentration series used cannot provide an inhibitory response to the growth of gram-positive or gram-negative bacteria.

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2. Determination of Minimum Inhibition Concentration (MIC) by Quantitative Liquid Dilution method using Uv-Vis spectrophotometry

In this study, MIC qualitatively showed bacterial growth in all test solutions, for that advanced MIC test is needed only to find out at what concentration, bacterial growth has the smallest difference which indicates the inhibitory ability of QT-CS Nanoparticle test solution to bacterial growth.

Table 3. MIC absorbance value against *Enterococcus faecalis*

Test Solution	Absorbance Value before incubation	Absorbance value after incubation	Value difference before and after incubation
50%	3.191	3.479	0.288
25%	1.937	2.457	0.52
12.5%	1.123	1.883	0.76
6.25%	0.754	1.709	0.955
3.13%	0.651	1.59	0.939
1.56%	0.713	1.477	0.764
0.78%	0.633	1.6	0.967
0.39%	0.662	1.463	0.801
0.20%	0.662	1.42	0.758
0.10&	0.632	1.27	0.638
Neg Ctrl	0.684	1.525	0.841
Pos Ctrl	0.652	0.233	-0.419

Table 4. MIC absorbance value against *Proteus vulgaris*

Test Solution	Absorbance Value before incubation	Absorbance value after incubation	Value difference before and after incubation
50%	3.397	3.661	0.264
25%	1.867	2.643	0.776
12.5%	1.119	2.011	0.892
6.25%	0.836	1.688	0.852
3.13%	0.755	1.566	0.811
1.56%	0.731	1.427	0.696
0.78%	0.743	1.547	0.804
0.39%	0.72	1.636	0.916
0.20%	0.715	1.625	0.910
0.10%	0.719	1.364	0.645
Neg Ctrl	0.724	1.622	0.898
Pos Ctrl	0.254	0.227	-0.027

The results of the Inhibition Zone Diameter study showed no killing power of QT-CS nanoparticles against *Proteus vulgaris* and *Enterococcus faecalis.* However, the MIC results showed that QT-CS nanoparticles can slow bacterial growth at the highest concentration of 50%. This possibility occurs because the concentration has the smallest absorbance difference value compared to others, which is about 0.2. At a concentration of 0.1 - 25% has a fairly large difference value. The amount of the absorbance difference is based on the growth power of bacteria contained in the test tube. But in this study, the growth power of bacteria is not a point that will be tested and observed.

The lack of ability of QT-CS nanoparticle solution to inhibit growth is likely because the QT-CS nanoparticles have an active composition or compound that is unable to penetrate the biofilm wall of *Proteus vulgaris* and *Enterococcus faecalis.* In the C + tube containing 500

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ppm chloramphenicol solution has a negative difference, meaning that in the tube, chloramphenicol solution is able to kill bacteria during the incubation time. While the test solution and C- containing DMSO are positive which indicate bacterial growth during the incubation time.

3. Determination of Minimum Bactericidal Concentration (MBC) by Solid Dilution method

The results of the MBC value test are shown in **Figure 5**.

(a) (b)

Figure 4. Growth of *Enterococcus faecalis* (a) and *Proteus vulgaris* (b) at 12 concentration series

The results obtained are observed visually directly. The results showed that in all petri dishes that had been filled with MHA media and dripped with a sample solution of 10µL with each concentration used, both were still able to grow which was characterized by the appearance of spots on the MHA media used. This shows that all concentrations used in this MBC study are not able to kill bacteria.

Harmonious research related to quercetin and chitosan conducted by Herslambang obtained inverse proportional results between concentration and inhibition zone. It is stated that the greater the concentration used, the smaller the minimum inhibitory zone [17]. This is because in research the phenol group (-OH) owned by quercetin will be bound to distilled water added as solvents to dilution and distilled water used in the nanoparticle synthesis process, resulting in decreased antibacterial inhibition. Another result that can be concluded is that the possibility of quercetin in high concentrations, cannot spread out because the cohesion force is greater than the adhesion force so that the spread of quercetin affects the effectiveness of quercetin in killing bacteria. Especially because the results of this QT-CS nanoparticle solution are suspended which has a viscosity due to the addition of chitosan.

Conclusion

1. The higher the concentration of NaTPP used, the greater the size of the nanoparticle suspension produced.
2. The results of colloidal nanoparticles have a viscosity of 15.5190 mPa.s, a density of 1.0404 kg / L, have a bright yellow colloidal color and have an Acidic pH, and a refractive index of >1.070.
3. QT-CS nanoparticles have no potential as antibacterial agents

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Adsorption of Fe Metal Analysis in Wastewater Using Nano Chitosan Coated Corn Cobs Adsorbents from Green Mussel Shells

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Abstract. *This study aims to determine the most effective formulation of activated carbon coated with nano chitosan and to determine the characteristics and optimum absorption of activated carbon from nano chitosan-coated corn cobs from green mussel shells and applied for the adsorption of heavy metal Fe in wastewater. Corn cobs were carbonized at 600°C and activated with HCl then coated with nano chitosan from green mussel shells. The best formulation of activated carbon coated with nano chitosan from green mussel shells is 10:0.6% nano chitosan. The PSA results obtained the average distribution of nano chitosan particles which was 101.79 nm. The adsorbent characterization was carried out using FTIR and BET instruments and the Fe metal analysis was carried out with AAS (Atomic Absorption Spectrophotometry). The FTIR characterization results obtained that the chitosan functional group (-NH) was present in wave number 3400.33 cm^{-1}, and the BET results obtained a surface area of 65.626 m^2/g and pore volume of 0.065 cm^3/g. The optimum conditions for absorption of Fe metal with activated carbon coated with nano chitosan were at a mass of 1 gram and with a contact time of 20 minutes. The absorption efficiency of activated carbon is 86.73% and activated carbon coated with nano chitosan is 89.91%. The wastewater samples added with activated carbon coated with nano chitosan were able to reduce the concentration of Fe metal in the wastewater samples from a concentration of 22.905 ppm to 2.54 ppm.*

Keywords: Adsorbent, corn cobs, nanochitosan, activated carbon, and adsorption.

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Introduction

Heavy metals Iron (Fe) is classified as a heavy metal that is essential in the body, in certain amounts it is needed by the body, but it is toxic if the amount is high [1]. In water, the presence of iron, cadmium, and chromium metals is very dangerous because these metals are very toxic metals [2]. According to research [3] water that contains a lot of Fe will turn yellow and corrode objects made of metal. Fe can also accumulate in the alveoli, causing reduced lung function [4]. If not properly protected, iron can catalyze reactions involving the formation of radicals which can damage biomolecules, cells, tissues, and whole organisms [5]. Based on research [6], corn cobs can be used as activated carbon and are able to absorb Fe metal. Corn cobs contain 41% cellulose and 36% hemicellulose which is a content that has the potential to make charcoal [7].

Corn is a food that is widely consumed in Indonesia. The high consumption of corn causes an increase in cob waste which can cause environmental pollution. Have conducted research on the use of corn cobs activated charcoal to purify used cooking oil [8]. Green mussels are organisms that have a pair of valve shells and are referred to as bivalves, 30% of the total weight of the green mussel shell is meat. Green mussels are one of the natural products produced in Indonesia and can be obtained by catching [9]. One of the most widely consumed sources of fish in Indonesia is green mussels and is part of the cultivated shellfish. This causes an increase in shell waste and has the potential to pollute the environment, although shells containing chitin can be used to produce chitosan. However, this group's shell waste has not been utilized optimally, so it can cause environmental pollution [10].

Chitosan can be obtained by deacetylating it using NaOH [11]. Previous research on green mussel shells, among others [12] used green mussel shells as a water purification coagulant and produced data that chitosan from green mussel shells is capable of purifying water [13] also used chitosan from green mussel shells as an environmentally friendly edible film. In his research [14] also used nano chitosan from green mussel shells to coat activated carbon to increase the adsorption power of activated carbon adsorbents for Stannum metal. Based on previous studies, this research was intended to be carried out by utilizing corn cob waste and green mussel shells as an absorbent for the heavy metal Fe which can pollute the environment and is contained in liquid waste. The researcher wanted to know the effect of nano chitosan used as an activated carbon coating to absorb total Fe in liquid waste.

Methodology

Materials

The AAS (Atomic Absorption Spectrophotometer), *Particle Size Analyzer* (PSA), *Fourier Transform InfraRed (FTIR), Brunauer Emmet Teller* (BET) instruments, analytical balance, shaker, desiccator, magnetic stirrer, Whatman No. 42 filter paper, spray bottle, dropper, beaker, pH meter, funnel, flasks of 25 milliliters, 50 milliliters, and 100 milliliters, and watch glass are the instruments used in this study. wastewater samples, corn cobs, green mussel shells, aqua dest, HCl, NaOH, HNO_3, CH_3COOH, a standard solution containing 1000 mg/L of Fe, and acetone were all used in this study.

Procedure

Carbon Preparation from Corn Cobs Waste and Activation

Corn cobs were obtained from a corn plantation in an agricultural area in North Sumatra. Corn cobs are then cleaned and cut into small pieces and then dried in the sun. The corncobs are then baked in the oven at 100°C for one hour to dry, this stage is a dehydration process. Then the

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material is burned in the furnace for 15 minutes at a temperature of 600°C. The resulting charcoal is then crushed and then sieved with a 200-mesh sieve. The charcoal obtained is then activated with a solution of hydrochloric acid (HCl) to obtain activated charcoal. The charcoal obtained was weighed as much as 50 g and added 250 mL of 1 M HCl. Stir using a magnetic stirrer for 30 minutes and then let stand for 24 hours. Filter the solution formed with Whatman filter paper and then rinse with distilled water. Then dry the activated charcoal in the container at 105°C using an oven for 1 hour to remove the water content contained in the activated charcoal [15].

Isolation of Chitosan from Green Mussel Shells

• **Preparation of Green Mussel Shells.**

The shells are dried in the sun. After drying pounded until the size is getting smaller. Then grind it using a grinder to form a fine powder. Then the green mussel shell powder was sieved with a 200 mesh sieve [16].

• **Deproteination Stage**

Prepared 70 grams of green mussel shell powder then added 3.5% NaOH with a ratio of 1:10. Heat at 70°C for 2 hours while stirring. Then the mixture was filtered and rinsed with distilled water until the pH was neutral. The solid obtained is then dried in an oven at 60°C until constant weight.

• **Demineralization Stage**

The deproteinated powder was added with 1N HCl in a ratio of 1:10. Then let stand at room temperature for soaking then heat at 75°C for 1 hour while stirring. Then the mixture was filtered and rinsed with distilled water until the pH was neutral. The solid obtained is then heated at 60°C to a constant weight. Chitin will be obtained from green mussel shells.

• **Deacetylation Stage**

10 grams of chitin powder was added to 60% NaOH (1:10) and heated at 90°C for 3 hours while stirring. Filter and rinse with distilled water until the pH is neutral. The solid obtained was then dried at 60°C to a constant weight. Chitosan will be produced as a product of this process.

Provision of Activated Carbon Coated with Nano chitosan

As much as 10 g of activated carbon was added to 100 mL of 0.2% nano chitosan solution, then stirred thoroughly and dried at room temperature for 3 days (Siregar, 2009). Variations were made on the concentration of nano chitosan, namely 0.4%, 0.6%, 0.8%, and 1.0% to determine the most effective formulation.

Adsorbent Characterization

The adsorbent produced was then characterized with several instruments, namely: PSA analysis to determine the distribution of particles in chitosan samples, FTIR analysis to analyze chitosan functional groups, and BET analysis to analyze the pore properties of carbon, activated carbon, and activated carbon coated with nano chitosan.

Provision of Fe Standard Solution for AAS Analysis

Weigh the solid $Fe(NO_3)_2$ ± 3.2142 g into a beaker glass containing 25 mL of distilled water, then stir until dissolved. Then the solution was put into a 1000 mL volumetric flask and diluted using distilled water up to the mark, then homogenized. Obtained a standard solution of Fe 1000 ppm. The standard solution was diluted to obtain a Fe solution with various concentrations of 0 ppm, 1 ppm, 2 ppm, 3 ppm, and 4 ppm as the standard solution for AAS analysis.

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Determination of Absorbance of Activated Carbon Coated Nano Chitosan with Variations in Mass and Contact Time

As much as 1 g of activated carbon coated with nano chitosan was then put into a beaker containing 100 mL of 10 ppm Fe standard solution. Stir with a magnetic stirrer for 10, 20, 30, 40, and 50 minutes, then filter. The filtrate obtained was then analyzed with AAS. Then the same thing was done on samples with variations in the adsorbent weight of 1 g, 2 g, 3 g, 4 g, and 5 g with the optimum time obtained.

Adsorption Analysis of Fe Metal with Activated Carbon and Activated Carbon Coated with Nano chitosan in Liquid Waste with AAS

As much as 1 g of corn cob-activated carbon adsorbent was added to 100 mL of wastewater sample. Stir until homogeneous using a magnetic stirrer for 10 minutes. The filtrate obtained was then analyzed with AAS. The same thing was done with activated carbon adsorbents coated with nano chitosan with the same mass and contact time.

Results and discussions

The activation process of corn cobs carbon was carried out by adding 250 mL of 1M HCl to 50 g of corn cob carbon to obtain activated carbon with a moisture content of 4.85%. The function of carbon activation with HCl is to form pores on carbon. The concentration of HCl used can affect the absorption capacity of the carbon. HCl concentrations that are too high can damage carbon and reduce its adsorption power, while HCl concentrations that are too low will be less able to open pores in carbon [17]. Charcoal activated with HCl has better absorption compared to other acid activators. Chitosan which had been isolated from green mussel shells was then characterized by PSA and FTIR. The purpose of the PSA (Particle Size Analyzer) analysis is to determine the particle size of chitosan. The chitosan solids obtained were then analyzed using PSA to obtain a graph of the particle size distribution as shown in **Fig 1**.

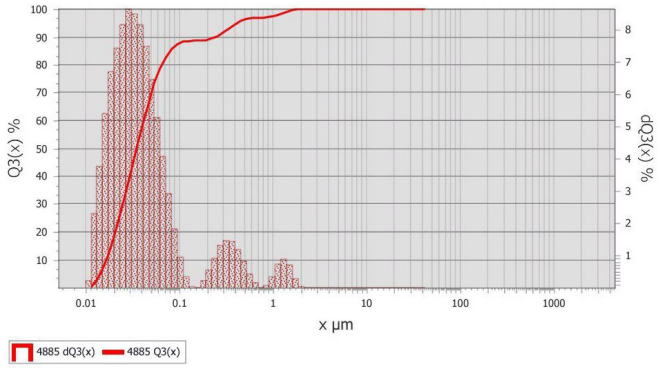

Figure 1. Graph of chitosan particle size distribution

Based on the data from the results of the PSA analysis that has been carried out, the particle size distribution data obtained and the average chitosan particle size is 101 nm. Nano chitosan has a particle size range of 100-400 nm [18]. Chitosan is converted into nanoparticles with a range of 100-400 nm [19]. The same thing so that the resulting chitosan can be classified as nano-sized [20].

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Chitosan characterization was also carried out using FTIR instruments to detect the presence of amine groups in chitosan, resulting from transformation from acetamide. The results of chitosan analysis with FTIR produce graphs as shown in **Fig 2**.

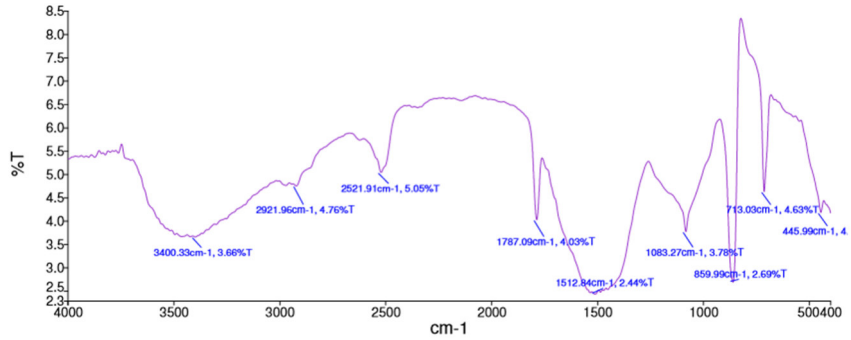

Figure 2. Chitosan IR spectrum

The results of the FTIR characterization showed that the absorption band of the chitosan samples analyzed indicated the presence of the N-H functional group belonging to chitosan at wave number 3400.33 cm-1. At wave number 2921.96 cm-1, the presence of the C-H functional group, the C-O functional group at wave number 1787.09 cm-1, and the C-N group at wave number 1512.84 cm-1 were detected. The identification of the N-H functional group belonging to chitosan indicates that chitosan has been successfully formed. The results of BET analysis on Carbon, Activated Carbon, and Activated Carbon coated with Nanochitosan samples can be seen in **Fig 3** below:

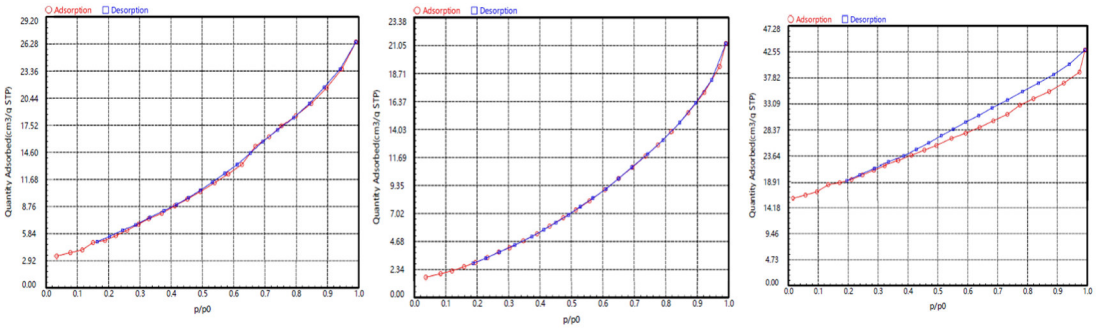

Figure 3. Carbon, activated carbon, and activated carbon coated with nano chitosan isotherm curve

According to the classification of adsorption isotherms, the graph above is a type III isotherm group and belongs to the mesoporous size with pore sizes between 2-50 nm [21]. BET analysis result showed that the surface area of corn cob carbon was 23.241 (m^2/g), the activated carbon was 14.395 (m^2/g), while the activated carbon coated with nano chitosan was 65.626 (m^2/g). BJH data for the surface area of corn cob carbon were 35.058 (m^2/g), activated carbon on corn cob was 24.445 (m^2/g), and activated carbon coated with nano chitosan was 36.770 (m^2/g). Analysis of adsorbent absorption of corn cobs activated carbon and nano chitosan-coated activated carbon was carried out by applying 1 gram of adsorbent to 100 mL of wastewater sample. Then analyzed using AAS so that data is obtained as in **Table 1**.

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Table 1. Adsorption of activated carbon and activated carbon coated with nano chitosan

No	Adsorbent	Sample mass (g)	Initial [Fe] (ppm)	Final [Fe] (ppm)	Capacity (mg/g)	Efficiency (%)
1	Activated Carbon	1	22.905	3.039	1.9866	86.73
2	Activated carbon coated with nano chitosan	1	22.905	2.54	2.0365	88.91

Based on Table 1 it can be seen that the absorption capacity of activated carbon is 1.9866 mg/g with an efficiency of 86.73%. Activated carbon coated with nano chitosan experienced an increase in capacity up to 2.0365 mg/g with an efficiency of up to 88.91%, so coating activated carbon with nano chitosan changed the absorption capacity of the activated carbon. The liquid waste samples added with activated carbon coated with nano chitosan were able to reduce the concentration of Fe metal in the liquid waste samples from a concentration of 22.905 ppm to 2.54 ppm. This reduction reached an absorption efficiency of 88.91%. Based on the wastewater quality standard which states that the total Fe is 5 ppm, the concentration of 2.54 ppm which has been reduced by the adsorbent is classified as safe wastewater.

Conclusion

The most effective composition formulation for nano chitosan-coated activated carbon adsorbent from green mussel shells is at a ratio of 10 g of activated carbon coated with 0.6 g of nano chitosan where the formulation is able to absorb Fe metal in solution with an efficiency of 88.91%. The results of the FTIR characterization showed that there was a chitosan functional group in the nano chitosan sample at wave number 3400.33 cm-1 which is a functional group (–NH). The results of the characterization of PSA nano chitosan showed that the average distribution of nano chitosan particles was 101.79 nm. The results of the BET characterization of carbon, activated carbon and nanochitosan-coated activated carbon showed that the highest surface area and pore volume were nanochitosan-coated activated carbon with a surface area of 65.626 m^2/g and a pore volume of 0.065 cm^3/g. Wastewater samples added with activated carbon coated with nano chitosan were able to reduce the concentration of Fe metal in the wastewater samples from a concentration of 22.905 ppm to 2.54 ppm. This reduction reached an absorption efficiency of 88.91%. Based on the wastewater quality standard which states that the total Fe is 5 ppm, the concentration of 2.54 ppm which has been reduced by the adsorbent is classified as safe wastewater.

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Simulation Study of Dibutylditiocarbamate (DBDTC) Ligand Molecular Dynamics for Extraction of Rare Earth Elements

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Abstract. *Separation and purification of Rare Earth Elements (REEs) is difficult because REEs have similar characteristics to one another. Separation using complexing ligand dibutyl dithiocarbamate (DBDTC) as extractants in the extraction. The aim of this study was to determine which ligands with the highest selectivity could distribute better into the organic phase for REE separation through molecular dynamics studies. The computational methodology uses the BIOVIA Discovery Studio 2016 molecular modeling program including the preparation of DBDTC and complex compounds with REEs. Then, I simulated and optimized the energy using the AMBER18 program. The simulation results show that the LTJ complex is still unstable as seen from the high fluctuation value of the bond length between the central REEs and the DBDTC and a stable complex has not yet been formed.*

Keywords: rare earth elements, DBDTC ligand, molecular dynamic

Introduction

Rare earth metals, as the name suggests, are very rare elements found in the form of complex compounds of phosphate and carbonate [1] . Rare earth elements are found together in nature, in various minerals, such as bastnasite, monazite, xenotim, and others [2]. Rare earth elements have highly reactive properties towards water and oxygen, form stable compounds in oxide conditions, have relatively high melting points, and are high heat conductor materials [3].

Rare earth elements are needed for various technological applications. The level of need for rare earth elements is increasing over time. A number of technologies that use rare earth elements include are electronic technology, optoelectronics, superconductors, super-magnets, lasers, computers, portable hydride batteries, and glass and ceramic materials. Elemental production Rare earths worldwide reach 70,000 tons per year [4].

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The elements La, Tb, and Lu are a type of lanthanide from the rare earth elements. Gd and Sm can be found in several types of rare earth metals, especially in monazite and bastnazite. This element has been isolated recently using solvent extraction and ion exchange techniques. Therefore, the extraction of metals La, Tb, and Lu continues to be developed to get better methods. This metal has the valence is in the form of 3^+ ions (trivalent) which are the same as the metals La, Tb, and Lu, so when extracting the metals La, Tb, and Lu are still mixed a method is needed or other extracting ligands in order to separate the metal. However, its effectiveness and efficiency are still felt to be lacking [5].

Separation of rare earth element metals can be done using various separation methods, the other is by using a complex ligand. The ability of rare earth elements to form complex compounds with several ligands has been proven by several studies, such as using di-butyl-dithiocarbamate (DBDTC) and di-butyl-dithiophosphate (DBDTP). Dibutyldithiocarbamate compounds can form complexes with a number of elements, especially the lanthanide group so that the ligand is dibutyl dithiocarbamate could be an option for the synthesis of complex compounds marked with the radioisotope ^{177}Lu as a radioisotope tracer in the industrial sector. The advantage of the ligand containing long alkyl groups, such as butyl is inward extraction efficiency organic phase is higher compared to ligands containing alkyl groups shorter ones, such as ethyl or methyl. The longer the alkyl chain, the more its nature is increasingly non-polar so that complexes are formed more easily extracted to the organic phase. Lanthanide elements can form compounds neutral complex with dibutyl dithiocarbamate ligand and soluble either in the organic or oil phase [6].

The dibutyl dithiocarbamate ligand is obtained by reacting carbon disulfide, ammonia, and dibutylamine. DBDTC ligand is slightly soluble in water, but completely soluble in organic solvents so it can be concluded that this ligand has properties semi-polar, this is in accordance with what was expressed by Snell and Effrey (1976) that the longer the alkyl group in the dialkyl dithiocarbamate ligand, the Its polarity will decrease so it will dissolve more easily in solvents organic [7].

Research about Gadolinium extraction with the DBDTC ligand has previously been carried out by several researchers. One of them was carried out by Taufan in 2008 who conducted research on the separation of gadolinium metal using the extraction method The solvent uses the DBDTC ligand, but the extraction efficiency results are poor obtained was 20.8%. To overcome these difficulties, it is necessary to use a more selective extractant.

Based on the explanation above, research will be carried out to compare DBDTC ligands as REE extractants (La, Tb, and Lu). To minimize costs and time, studies are used in computational chemistry of molecular dynamics. The study carried out tested LTJ complex (La, Tb, and Lu) with DBDTC ligand by using two solvent simulations explicitly. Expected with Making this DBDTC ligand will increase the extraction efficiency results obtained.

One of the uses of computational chemistry is to model a molecular system that will be synthesized in the laboratory. Even though it's a model computing can't be perfect, but it can be very good to predict about 90% of reality. This is very useful because to synthesis of chemical compounds requires a lot of costs and raw materials, and can produce materials dangerous waste. Another use is to understand chemical problems in more detail. Some properties of molecules can be calculated more easily by computational means compared with the experimental method [8].

Molecular Dynamics (MD) or Dynamics Molecular is a computational technique in carrying out simulations over a period of time specific to observe the biological function of incapacitated proteins or nucleic acids observed experimentally. In MD simulations, time

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characteristics and length of the simulation an important thing to consider [9].

Steps that need to be considered before carrying out simulations are system preparation including molecules, ions, solvents, and ligands. At stage preparation, adjustments are made as closely as possible to the circumstances of the experiment to be carried out, one of which is the physical properties the chemistry of the molecules to be simulated, the choice of solvent, and the type of water that will be used taken into account. Next, minimization is carried out energy for molecules to become stable. The system is heated to a certain temperature, equilibrated density, pressure, volume, and energy as well production is carried out during the desired time [10].

Application of molecular dynamics to systems the solvent/solute allows this to be done calculation of system properties such as diffusion coefficients or a radial distribution function for use in statistical mechanics calculations. In general solvent/solute calculation scheme begins with a system consisting of a number of molecules with initial position and velocity. The main part of the methodology simulation is the availability of the potential energy function accurate way to model the properties of the system being studied. Potential energy functions can be constructed through quantum mechanical methods (Quantum Mechanics, QM) or molecular mechanics (Molecular Mechanics, MM) [11].

Therefore, it needs to be done carefully study of computational chemistry theory of molecular dynamics, to minimize costs and time. The study was carried out, namely testing the DBDTK ligand complex with LTJ (La, Tb, and Lu) by using simulated water as a solvent explicitly to obtain the appropriate ligand for extracting La, Tb, and Lu. This research It is hoped that this will explain the mechanism of DBDTC ligand selectivity towards ligands DBDTC in the separation of rare earth elements (La, Tb, and Lu) to obtain recovery results better to increase efficiency extraction in the laboratory.

Method

Material

The materials used for this research are DBDTC ligands and REEs complexes (La, Tb, and Lu) with DBDTC ligands.

Instrumentation

These are divided into two groups, namely devices hard (hardware) and software (software). The hardware consists of a PC (Personal Computer) with specifications as follows: Core i7 CPU 980 @3.33 GHz 980 processor, 8GB RAM, NVIDIA Ge Force GTX GPU 980 4GB, 2 TB hard disk, and software used is Biovia Discovery Studio Visualizer 2016, AMBER18, Amber Tools 17, Linux operating system, Visual Molecular Dynamics (VMD).

Procedure

This method is a reconstruction modeling carried out by Saqib and Siddiqi [12].

Preparation of DBDTC Ligand

The DBDTC ligand structure was created using BIOVIA Discovery software Studio 2016 and energy optimization was carried out. The ligand structure created is then saved in pdb file format.

Preparation of La, Tb, and Lu Complex Structures with DBDTC Ligands

The DBDTK ligand structure that was created was then connected to each central atom of La, Tb, and Lu using BIOVIA Discovery Studio 2016 software, and energy optimization was carried out and then saved in pdb file format.

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Simulation of Molecular Dynamics of La, Tb, and Lu Complexes with Ligands and Three Waters

Molecular dynamics simulations were carried out on the La, Tb, and Lu complexes with the prepared DBDTC ligands. The input file for the molecular dynamic simulation was prepared using the LEaP module and adding n-hexane as an organic solvent in AmberTools 17 which includes minimization, heating, equilibration, and production using the pmemd module in the AMBER 18 program. This simulation was carried out using explicit solvent for 100 ns with timesteps of 1 fs.

Visualization and Analysis of Molecular Dynamics Simulation Results

An analysis of the results of molecular dynamics simulations of the La, Tb, and Lu complexes with DBDTC ligands in a two-solvent system was carried out, including molecular dynamics trajectory analysis and visualization using VMD software. The results obtained were then compared with the results of donor atomic distance analysis, RDF, and energy of the La, Tb, and Lu complexes with DBDTC ligands.

Results and discussions

Analysis and Visualization of Molecular Dynamics Simulation Results

One of the advantages of molecular dynamics simulations is that water and organic solvent molecules can be added explicitly to the system. The organic solvent used is chloroform. Molecular dynamics simulations were carried out in this two-solvent system because this research will later be applied to extraction in the laboratory, so by carrying out this simulation, it is hoped that the stability, movement and distribution of the REE complex (La, Tb, and Lu) with the DBDTC ligand in the water solvent and n-hexane can be observed.

Molecular dynamics simulations were carried out on the REE complex (La, Tb, and Lu) with the prepared DBDTC ligand. Input files for molecular dynamics simulations were prepared using the LEaP module in AmberTools 17. Structure minimization was carried out using the AMBER18 program. Molecular dynamics simulations are carried out in several stages, namely input file preparation, parameterization, minimization, heating, equilibration, production, and analysis.

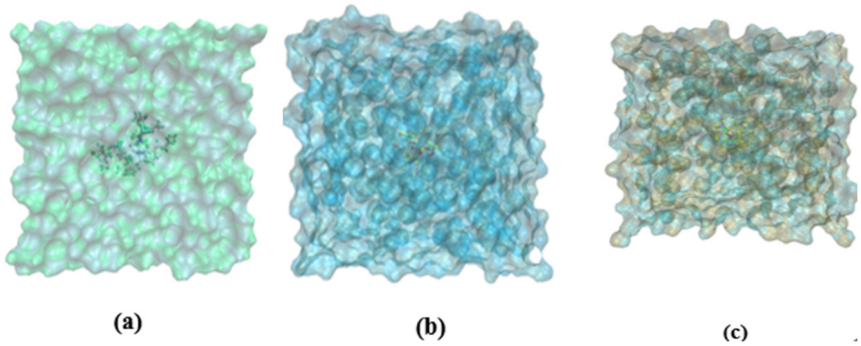

Figure 1. Molecular dynamics simulation in a water solvent system, (a) La-DBDTC complex in water BOX, (b) Tb-DBDTC complex in water BOX, (c) Lu-DBDTC complex in water BOX

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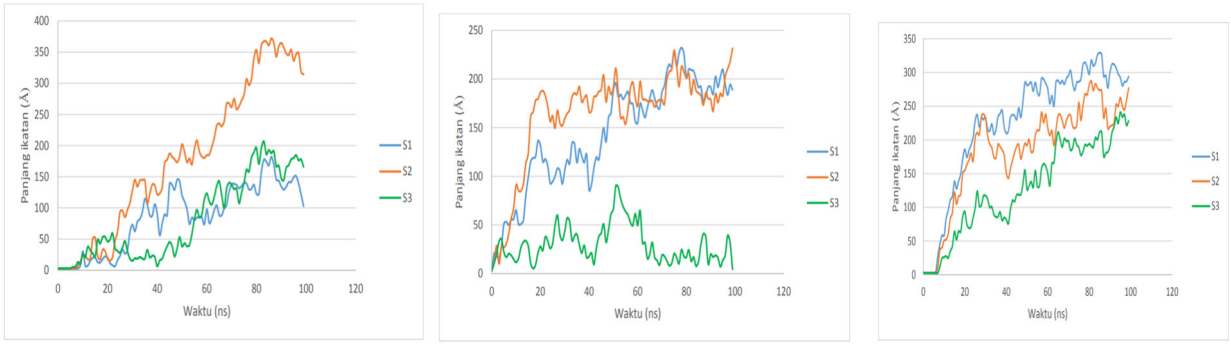
Next, the LTJ complex (La, Tb, and Lu) with the DBDTC ligand was simulated for molecular dynamics which included minimization, heating, equilibration, and production using the pmemd module contained in the AMBER18 program package.

Analysis of the results of molecular dynamics simulations was carried out for each REE complex structure (La, Tb, and Lu) with the DBDTC ligand in a two-solvent system from the molecular dynamics trajectory using VMD software. The results obtained were then compared with the results of donor atomic distance analysis, RDF, and energy of the REE complex (La, Tb, and Lu) with the DBDTK ligand.

1. Distance Analysis of LTJ Center Atoms (La, Tb, and Lu) and S Atoms in DBDTC Ligands

Analysis of the distance between the LTJ center atoms (La, Tb, and Lu) and the S donor atom in the DBDTC ligand was carried out. This analysis is carried out to determine how much movement the complex bond has between the central atom and the ligand. If during the molecular dynamic simulation, the movement does not show significant fluctuations, then the REE complex compound (La, Tb, and Lu) with the DBDTC ligand is a stable complex. Fluctuations in the distance of the LTJ central atom (La, Tb, and Lu) to the S donor atom in the DBDTC ligand can be seen in the following graph.



(a) **(b)** **(c)**

Figure 2 a. Distance graph between La-S in the La-DBDTC complex. Simulation results for 100 ns
b. Distance graph between Tb-S in the Tb-DBDTC complex. Simulation results for 100 ns
c. Distance graph between Lu-S in the Lu-DBDTC complex. Simulation results for 100 ns

Figure 2 (a) to (c) show changes in the distance of the LTJ central atom (La, Tb, and Lu) to the S donor atom in the DBDTK ligand (Å) with respect to time (ns). S1 refers to the S donor atom of DBDTC ligand number 1. S2 refers to the S donor atom of DBDTC ligand number 2, and S3 refers to the S donor atom of DBDTC ligand number 3.

Based on this graph, all LTJ complexes (La, Tb, and Lu) with the DBDTC ligand do not form a stable complex. This can be seen from the high fluctuation in the distance of the LTJ central atom (La, Tb, and Lu) with the S donor atom in the DBDTC ligand. So, it can be concluded that in less than 10 ns, all the ligands have been released from the complex as indicated by the significant increase in the distance of the LTJ central atom (La, Tb, and Lu) to the S donor atom in the DBDTC ligand. So, with these results, the LTJ complex (La, Tb, and Lu) with the DBDTC ligand cannot form a stable complex and has experienced decomposition over the length of time of the molecular dynamics simulation.

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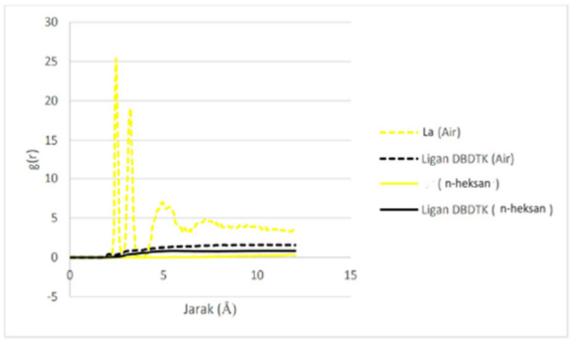
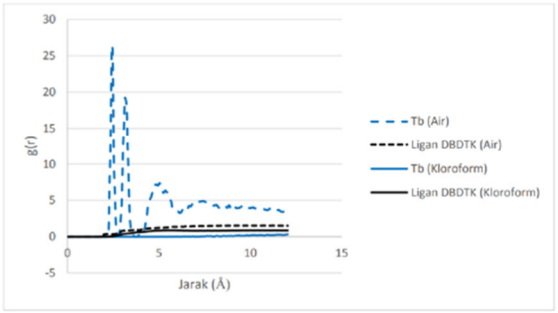
2. RDF Analysis of REEs (La, Tb, and Lu) with DBDTC Ligands

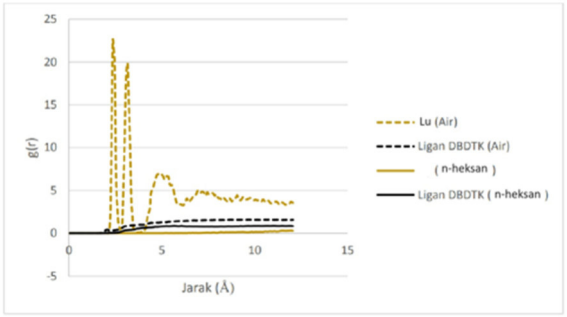
RDF (Radial Distribution Function) analysis was used to observe the distribution of REE complex compounds (La, Tb, and Lu) with the DBDTC ligand. RDF analysis was chosen because it is more universal for finding out how to represent a molecule with more than one solvent system. Because the REE complex (La, Tb, and Lu) with the DBDTC ligand does not form a stable complex, in this RDF analysis only the distribution of the central atom of the REE (La, Tb, and Lu) with the DBDTC ligand in water and n-solvents is compared. hexane. The results are shown in the Figure below



(a)



(b)



(c)

Figure 3 a. Comparison graph of RDF in La with DBDTC ligand
b. Comparison graph of RDF in Tb with DBDTC ligand
c. Comparison graph of RDF in Lu with DBDTC ligand

Figure 3 (a) to (b) show that all REEs central atoms (La, Tb, and Lu) are more distributed in the water solvent compared to the organic solvent. Likewise, DBDTC ligands are more distributed in water solvents compared to organic solvents. However, the difference in the distribution of the DBDTC ligand is not too great, the difference is only around 0.4. This is because the DBDTC ligand is slightly soluble in water but completely soluble in organic solvents. So, it can be concluded that the DBDTC ligand has semi-polar properties.

3. Energy Analysis

Energy analysis was carried out to determine the stability of the REE complex (La, Tb, and Lu) with the DBDTC ligand from the energy of the REE complex (La, Tb, and Lu) with the DBDTC ligand. In this energy calculation, the GBSA (Generalized Born Surface Area) method is used, which can be used to calculate the interaction energy of charges in solvent media and several terms

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on the surface, such as hydrophobic interactions, van der Waals interactions, and so on [13]. The results of energy calculations for the LTJ complex (La, Tb, and Lu) with the DBDTK ligand are shown in the following table. The DBDTC ligand has the highest stability.

Table 1. Calculation of energy for the REE complex (La, Tb, and Lu) with the DBDTC ligand using the GBSA (Generalized Born Surface Area) method

LTJ	Δ G (Kkal/mol)	Deviation Std	Standard Error
La	5.4345	32.2404	5.3021
Tb	17.7425	28.5179	5.5445
Lu	9.6864	23.5872	2.3657

From these results, it can be seen that the energy values of all complexes are relatively large. This is in accordance with the results of the distance analysis of the LTJ central atom (La, Tb, and Lu) with the S donor atom, so it is true that this complex does not form a stable complex.

Visualization of Molecular Dynamics Simulation Results

(a) (b)

Figure 4. Structure of the LTJ complex (La, Tb, and Lu) with the DBDTC ligand (a) at 1 ns, (b) at 10 ns

From the figure, it can be observed that at the start of the simulation, namely at 1 ns, the LTJ complex (La, Tb, and Lu) with the DBDTK ligand is still bound. However, when 10 ns entered, the LTJ complex (La, Tb, and Lu) and the DBDTC ligand were no longer bound, as indicated by the release of the ligand away from the central atom of the REE (La, Tb, and Lu). At what time the ligand starts to release can be seen from the high fluctuation value of the distance of the LTJ central atom (La, Tb, and Lu) to the DBDTC ligand. This applies to the REE complex (La, Tb, and Lu) with the DBDTC ligand. This means that the LTJ complex (La, Tb, and Lu) with the DBDTC ligand cannot form a stable complex and has undergone decomposition over the length of time of the molecular dynamic simulation.

Conclusions

1. The LTJ complex (La, Tb, and Lu) with the DBDTC ligand is an unstable complex.
2. The REE complex (La, Tb, and Lu) with the stable DBDTC ligand was not formed so its distribution in the water phase and organic phase could not be observed.

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Conversion of Durian (*Durio zibethinus*) Seed Waste into Bioethanol

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Abstract. *The diminishing of fossil energy supply is real. Indonesia used to be an oil exporter country, however, now it has become an importer of oil. The development of sustainable energy is in critical need. Moreover, Indonesia as an agricultural country is rich in biomass waste. The idea of this project is to study the possibility of using biomass waste as a source of bioethanol. In this case, durian seed as a biomass waste can be converted into bioethanol. The process of converting durian seed is started by making durian seed flour. The process is followed by hydrolysis of durian seed flour. The final step is fermentation and purification. The purpose of purification is to reduce the water content of the bioethanol. The purification*

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of the bioethanol combines a distillation process with an absorption process. Furthermore, this project utilizes two different adsorbents: silica gel and CaO. The bioethanol has a density of 0.8692 g/ml, a viscosity of 1.030 cp, and a 45% of ethanol. Finally, FTIR analysis indicates the existence of all the functional groups related to ethanol.

Keywords : bioethanol, biomass waste, renewable energy, durian seed

Introduction

Fossil fuel is the most important energy source used in industry, transportation, or households. However, with its use as an energy source, the need for petroleum is increasing and is not balanced with the amount of production, which can cause an energy crisis. [1] Therefore, to prevent excessive dependence on petroleum, what needs to be done is to reduce the use of petroleum. To reduce the excessive use of petroleum and prevent future petroleum crises, the solution developed is now a New Renewable Energy (NRE) source. [2]

Renewable energy sources are renewable and if managed properly, these resources will not run out. Therefore, people can reduce the use of petroleum through renewable alternative energy which is often called Biofuel. [3] The current biofuel developed is biodiesel/biosolar, biohydrogen, and bioethanol.[4] Furthermore, reducing our dependence on fossil energy will reduce the amount of carbon released into the air. [5] Indonesia as an agricultural country has an abundance of biomass. Previous researchers have used sugar cane, cassava, corn, pineapple skin waste, and breadfruit. [6] The problem with all the previous examples is all of them are food sources. It will be convenient if there are non-edible sources of bioethanol. The proposed nonedible biomass is Durian fruit (*Durio zibethinus).* North Sumatra province produced 1 million tons of durian fruit in 2020 (Data source from the Central Bureau of Statistics). Referring to the data above, the waste produced by durian fruit is massive but has not been used. The utilization of durian seed waste will increase the economic value of durian.

This study began by converting glucose from durian seed waste (*Durio zibethinus*) into bioethanol using *the separate hydrolysis and fermentation* (SHF) method. Furthermore, bioethanol purification is carried out by distillation method. The final stage of the study was the determination of bioethanol levels using UV-VIS spectrophotometry. The objectives of this study are: (1) Knowing the bioethanol yield of durian seed waste *(Durio zibethinus*) with *separate hydrolysis and fermentation* (SHF) methods. (2) Knowing the characteristics of bioethanol from durian seed waste *(Durio zibethinus*) by *separate hydrolysis and fermentation* (SHF) method. From this research, it is expected that bioethanol can be produced.

Results and Discussions

The conversion process of durian seed into bioethanol will proceed into several processes. The first process is turning durian seed into flour. The reason for making durian seed flour so that the raw material can be hydrolyzed easily.

Durian seed is dried and ground into a brown color flour. The purpose of making durian seed flour is to make sure that the sample can be stored for several weeks. In the previous trial, we did not prepare the sample in flour form and the lifetime of the sample was too short. The sample is quickly gone bad. The first step carried out in this study is to prepare 20 kilograms of durian seeds and then the durian seeds are soaked and washed until completely clean from the remaining fruit flesh that is still attached. Then dry the clean durian seeds for 3 days to 5 days by air drying

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until the seeds peel off from the outer skin. In the last stage, the dried durian seed meat core is mashed using a grinder until it becomes powder or flour. After that, durian seeds that have become powders are filtered with an 80 mesh sieve to get a finer powder. The results of the preparation stage proceed to the hydrolysis stage. [7] Figure 1 exhibits the brown color of durian seed flour. The brown color flour is then under the treatment of hydrolysis. The hydrolysis process utilized acid treatment which is HCl. The acid treatment is then followed by the heating procedure. The final step of durian seed hydrolysis is filtration.

Figure 1: The transformation of durian seed into flour

Before the fermentation process, the yeast will be immobilized into a bead form. The purpose of immobilized yeast is to make sure the yeast will have a longer lifetime. The flour of Durian will be easily stored.

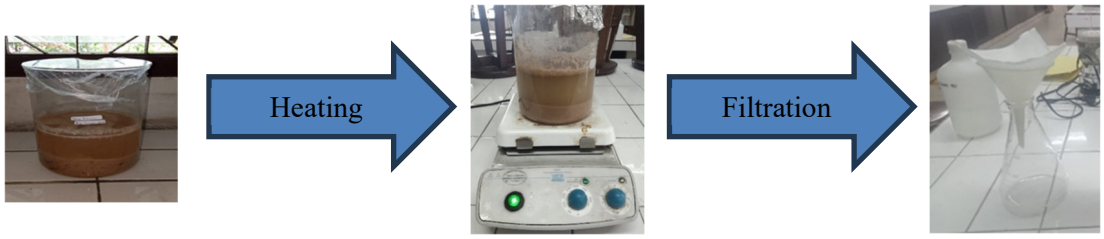

Figure 2: Hydrolysis and fermentation process

The fermentation stage is carried out by filtering the filtrate from the hydrolysis process. The filtrate will be put on the Erlenmeyer and NaOH or HCl to change the pH around 4.5 – 5. Figure 3 demonstrates the process from hydrolysis to fermentation. The final step of fermentation preparation is adding immobilization cell beads, 5% glucose, and urea onto the fermentation chamber. The fermentation chamber will be closed tightly and stored in a dark room for 96 hours.

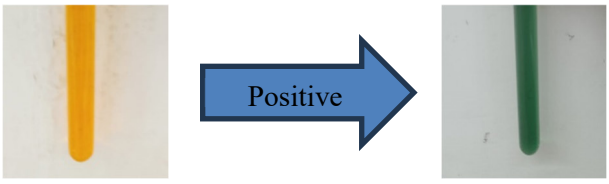

Figure 3: Color Testing of Bioethanol

After the fermentation is finished, the bioethanol will undergo the distillation and adsorption process. The fermented filtrate is filtered and then put into a round flask and assembled with a

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simple distillation tool. This distillation stage is carried out at a boiling point temperature of 78-80℃ ethanol and heated using a hotplate.

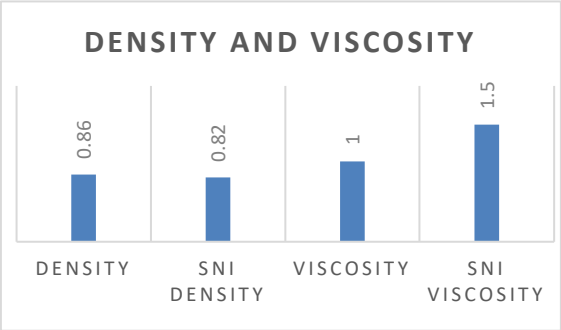

Figure 4: Physical characteristics of Bioethanol from Durian Seed

The next process is adsorption with silica gel. The ratio of adsorbent and distillate is 1:2 with an adsorption time of 12 hours. Then the adsorption results of each distillate sample with variations of silica gel were characterized qualitatively and quantitatively. The physical characteristics of durian seed's bioethanol are in liquid form, no color, and are dissolved in water. There are several qualitative and quantitative analyses will be performed on durian seed bioethanol. The first analysis is a positive test of bioethanol. The positive test of bioethanol was carried out by oxidation method using Potassium dichromate ($K_2Cr_2O_7$).

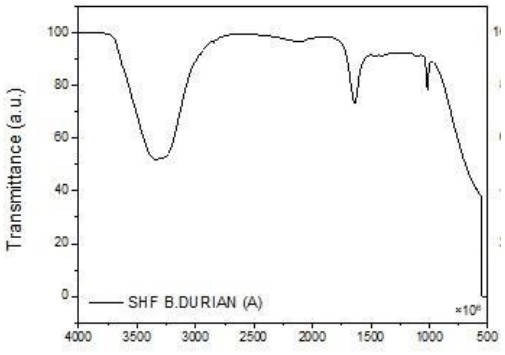

Figure 5: FTIR Spectra of Durian seed's bioethanol.

A positive result was indicated by the change in bioethanol's color. Figure 3 shows the positive result of bioethanol. The color changes from orange to bluish-green. [8] This indicates the presence of ethanol produced during the fermentation process. Ethanol is a primary alcohol compound where the C atom attached to the OH group binds 2 Hydrogen atoms. Potassium dichromate will oxidize bioethanol into acetic acid in a relatively short time. The oxidation process will change the color of potassium dichromate from orange to bluish-green after 1 drop of bioethanol. The bluish-green color comes from Cr^{3+} which is caused by the changing of oxidation state of Cr from +6 to +3.

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The second characterization is the determination of the density and viscosity of durian seed bioethanol. The density of bioethanol is performed by measuring the mass and volume of bioethanol. Using the density formula, $\rho = \frac{m}{V}$, the density of durian seed's bioethanol can be calculated. Figure 4 displays the density comparison between durian seed's bioethanol and the standard value. The standard value density is 0.82 $\frac{g}{mL}$, whereas durian seed bioethanol is around 0.86 $\frac{g}{mL}$.[9] The density of durian seed's bioethanol is close enough to the standard value. Furthermore, the viscosity is measured using an Ostwald viscometer. Furthermore, the viscosity of durian seed's bioethanol is around 1,000 cst whereas the standard viscosity for bioethanol is 1,525 cst. The viscosity result is a little bit off from the standard value. Figure 4 presents the comparison between density and viscosity of durian seed's bioethanol. The density and viscosity of bioethanol an important parameter for later when to be used in the machinery.[10] The viscosity will determine whether the bioethanol will flow smoothly during the operation of the machine. If the viscosity is too high then there will be difficulty in the combustion process of bioethanol.

The third characterization is FTIR. Information surrounding the functional groups of bioethanol can be identified. Figure 5 shows the FTIR of bioethanol absorbed using silica gel. There are around 4 peaks visible on the spectrum. The first peak is 3339 cm^{-1}. This peak corresponds to the OH bond or is specifically related to the hydrogen bond. The second peak that is visible is around 2000 cm^{-1}. This wavenumber corresponds to C-H bonds. The third peak is visible around 1500 cm^{-1}. The last peak was around 1000 cm^{-1}. The last peak is related to the C-O bond. [11] The peaks around 2000 cm^{-1} are not visible. This is due to the overwhelmingly strong peak around 3339 cm^{-1}. The data from FTIR indicated that the bioethanol produced from durian seed using the SHF method still contained a large composition of water. The future project should improve the method so that the water content can be reduced.

The fourth characterization is the utilization of Uv-Vis spectrophotometry. From this method, the concentration of bioethanol is around 3.8%. Positivity tests give a conclusion that there is bioethanol present, but FTIR and UV-VIS data indicated that the bioethanol is not pure. Strong absorbance around 3000 cm^{-1} weakens the other peaks.[12] Figure 6 presents the uv-vis curve that are used to calculate the concentration of bioethanol. [13] The concentration of durian seed's bioethanol using SHF method and silica gel adsorbent is 3.8%. It is quite low, and it is not possible to be used as bioethanol.

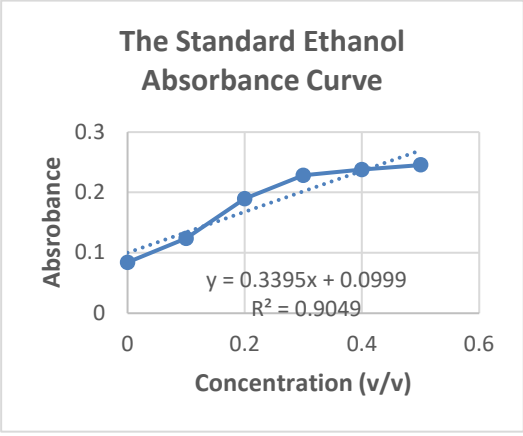

Figure 6. UV-Vis Curve Generated from Ethanol Standard Solution

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Conclusions

This research utilizes organic waste, namely durian seeds. The utilization of this organic waste is by converting durian seeds. This study resulted in several conclusions, namely" Bioethanol can be produced from durian seeds. Furthermore, the first physical characteristic is the density of *bioethanol* from Durian seeds with a value of 0.86. The second physical characteristic is the viscosity of *bioethanol* from Durian seeds is 1.027 cp. Furthermore, spectrophotometry data indicated that bioethanol produced still contained a large amount of water. Hence the preparation of bioethanol by implementing the SHF method and utilizing silica gel as an adsorbent is not optimum for durian seed samples. The future project will be using simultaneous saccharification and fermentation methods.

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Optimization of Fe-Cu activated carbon derived oil palm empty fruit bunches in reducing free fatty acid value and peroxide value of crude palm oil (CPO)

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Abstract. *Activated carbon with Fe-Cu modified were synthesized from Oil Palm Empty Fruit Bunches (OPEFB) and used as a biosorbent for carbon production at 500 ºC. Activated carbon and Fe-Cu modified activated carbon were characterized by FTIR. CPO quality parameters such as Free Fatty Acids and Peroxide Number were analyzed using the titration method to see the effect of adsorption on CPO quality. The characterization by FTIR show that the OPEFB biosorbent has a sharp absorption with O-H, C-H, and C-O content which indicates that the biosorbent contains cellulose. Activated carbon and modified activated carbon are amorphous and their pore sizes are mesoporous. Free fatty acid levels in CPO were 3.59% and then decreased after adsorption with activated carbon with a free fatty acid content of 3.19% and Fe-Cu activated carbon with a free fatty acid content of 2.84%. While the peroxide number in CPO were 2.89 meq O2/kg then decreased after adsorption with activated carbon with a peroxide number of 2.68 meq O2/kg and Fe-Cu activated carbon with a peroxide number of 2.49 meq O2/kg. The CPO quality standard for free leak acid and peroxide value according to SNI 01-2901-2006 is 5%, therefore the CPO used in this study is still in accordance with the existing quality standards. Fe-Cu activated carbon is considered better in reducing FFA and PV levels than CPO.*

Keywords: activated carbon, adsorption, crude palm oil, oil palm empty fruit bunches, free fatty acid value, peroxide number

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Introduction

The large area and high production rate are one of the reasons for the rapid development of the palm oil industry in Indonesia. Palm oil processing in the palm oil industry not only generates palm oil, but also produces waste. Thus, the high rate of palm oil production will also be followed by an increasing amount of waste produced [1]. Solid waste from the palm oil processing process consists of empty palm bunches, shells, fibers, sludge. The empty palm bunches solid waste is the main waste, which is about 16-23% of each palm oil refinery process [2]. Oil palm empty fruit bunches (OPEFB) contain 33.83%-34.85% cellulose, 1707%-18.05% hemicellulose and 26.71%-27.54% lignin. The high amount of cellulose in OPEFB can be converted into activated carbon by carbonization and activation [3].

Crude palm oil (CPO) is a natural source of carotenoids in the form of retinol (pro-vitamin A). Nowadays, industry is very competitive on CPO component properties such as free fatty acid, iodine value, peroxide value and oil content [4]. Palm oil has a natural red-colored pigment due to carotenoid pigments, which mainly consist of β-carotene. During this process, the red color in palm oil is usually eliminated. The removal of β-carotene is carried out as consumers would prefer the color of clear cooking oil instead of reddish cooking oil. Several methods of recovering carotenoid components from palm oil have been carried out including solvent extraction, transesterification, adsorption using synthetic resins, silica gel, chromatographic adsorption and membrane technology [5].

One of many adsorbent species developed and used for adsorption is activated. The activated carbon has great adsorption capacity and can be regenerated. The large adsorption potential is attributed to the large surface area, high porosity and functional groups such as carboxyl, carbonyl and hydroxyl on the surface of activated carbon [6]. According to Nurdjannah [7], CPO content levels including free fatty acids and peroxide values can be reduced by using modified biosorbents.

Methodology

Preparation of biosorbent

Oil palm empty fruit bunches (OPEFB) were collected from PT Multi Agrindo Sumatera. The collected OPEFB was washed using water and dried under the sun so that the water content is reduced. OPEFB was dried and chopped into small sizes. Afterwards, OPEFB was grinded using a grinder and sieved with a 200 mesh sieve. The biosorbent was then purified with distilled water.

Preparation of activated carbon

The prepared OPEFB sample was weighed and put into a furnace at 500 ºC for 2 minutes to conduct the carbonization process. The carbonized OPEFB was weighed and soaked in H_3PO_4 for 24 hours. Subsequently, the sample was filtered and washed with distilled water until the pH is neutral. The precipitate was dried in an oven at 105 ºC for 1 hour.

Modification of activated carbon

About15 grams of activated carbon was put into 150 mL of a mixture of $FeSO_4$ and $CuSO_4$ solutions in a ratio of 1: 1. Then, the mixture was heated at 60 ºC for 3 hours using a magnetic stirrer which was then cooled and filtered. The filtrated was put into the oven at 105 ºC for 24 hours.

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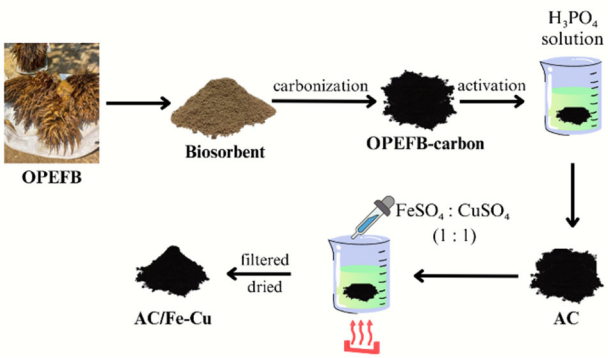

Figure 1. The illustration of activated carbon/Fe-Cu preparation

Free fatty acid analysis

About 5 g sample of CPO was pipetted and put into an erlenmeyer. Then, about 50 mL of neutral alcohol was added and heated on a water bath under stirring for 5 minutes. After cooling, 3 drops of phenolphthalein indicator were added. Then, the solution was titrated by 0.1 N KOH solution until a pink colour is formed [8].

Peroxide value analysis

Peroxide value analysis was performed following the previous research [9]. About 5 g of CPO sample was pipetted and added 30 mL of a mixture of glacial acetic acid and chloroform in a ratio of 3:2 then stirred until dissolved. Subsequently, 0.5 mL of saturated KI solution was added and tightly closed while shaking for 1-2 minutes, then stored in a dark room for 30 minutes. Then, about 30 mL of distilled water and 0.5 mL of 1% amylum solution was added into the solution. The mixture was titrated by 0.01 N sodium thiosulfate solution in small amount at a constant rate until the blue colour disappears

Result and discussion

FTIR Characterization of biosorbent

Biosorbent production was performed through simple steps. The preparation of biosorbent was following our previous work [10]. As we can observe, FTIR analysis was carried out to investigate the compound based on its functional group. As depicted in figure 2, the FTIR spectra shows a weak absorption at wave number at 3338.176 cm^{-1} indicates hydroxyl group, a strong and sharp absorption at 2917.77 cm^{-1} for carbonyl group.

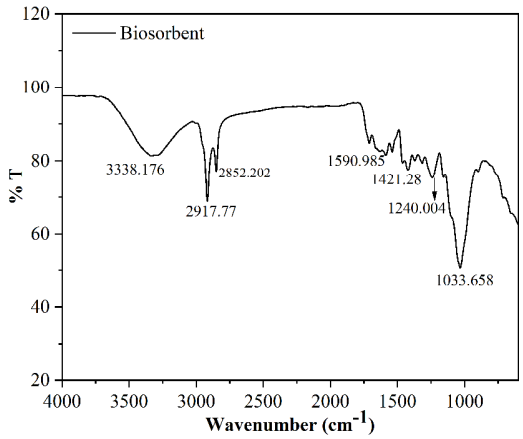

Figure 2. FTIR spectra of biosorbent

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The presence of C-O groups and O-H groups indicates the polarity of the biosorbent. The results of FTIR characterization analysis showed several functional groups which can be interpreted that there are a lot of cellulose contained in the biosorbent. These functional groups could interact with positively charged heavy metal ions, hence, enhancing their adsorption ability [11].

Free fatty acid analysis

In this study, the effect of β-carotene adsorption using activated carbon and Fe-Cu activated carbon from OPEFB biosorbent on CPO free fatty acid contents was investigated. The analysis was carried out to compare the free fatty acid content of CPO without adsorption treatment and CPO that was adsorbed under various contact times and optimal mass.

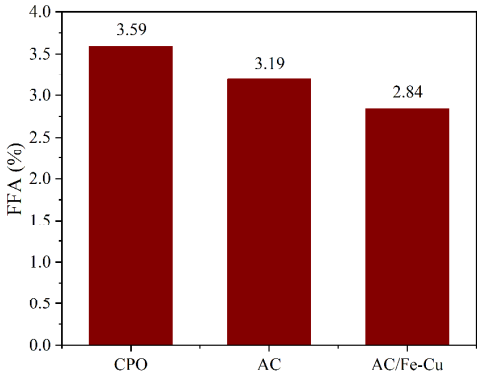

Figure 3. Free fatty acid analysis using activated carbon and activated carbon/Fe-Cu on CPO

Free fatty acid level in CPO has decreased after the β-carotene adsorption using activated carbon and activated carbon Fe-Cu (AC/Fe-Cu). The analysis results of free fatty acid levels in CPO amounted to 3.59%, then decreased after adsorption with activated carbon resulting 3.19% and AC-Fe/Cu is about 2.84%. Thus, it could be declared that the adsorption process of β-carotene using activated carbon and modified activated carbon from OPEFB has the potential to reduce the free fatty acid content of CPO. The activated carbon can reduce the free fatty acid content of CPO and AC/Fe-Cu proves to be more effective in decreasing the free fatty acid content of CPO. The CPO quality standard for free fatty acids according to SNI 01-2901-2006 is about 5%, hence the CPO used in this study is still in accordance with the existing quality standards.

During the adsorption process, the free fatty acids can be generated from hydrolysis and oxidation reactions involving high temperatures. The adsorbent has increased adsorption capability at higher temperatures thereby adsorbing the free fatty acid component produced during adsorption [12].

Peroxide value analysis

The peroxide number in CPO has decreased after β-carotene adsorption using activated carbon and AC/Fe-Cu. The result of the peroxide number analysis on CPO was 2.886 meq O_2/kg and then decreased after adsorption with activated carbon with a peroxide number of 2.699 meq O_2/kg and AC/Fe-Cu shows a peroxide number of 2.497 meq O_2/kg. Therefore, it can be stated that the β-carotene adsorption process using activated carbon and Fe-Cu modified activated carbon from OPEFB has an influence on reducing the peroxide number in CPO. Activated carbon could reduce the peroxide number in CPO while AC/Fe-Cu proved to be better in reducing the peroxide number in CPO.

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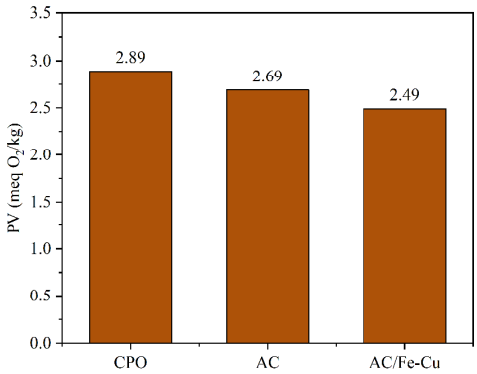

Figure 4. Peroxide value analysis using activated carbon and activated carbon/Fe-Cu on CPO

Conclusion

The production of biosorbents in an accessible approach has been successfully performed using OPEFB. The activation of carbon from OPEFB produced an improvement in adsorption ability. In addition, modification of activated carbon using Fe-Cu was found to exhibit better adsorption capability in reducing FFA and PV levels in CPO up to 2.84 and 2.49, respectively.

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Transformation of cinnamic acid in frankincense (STYRAX *paraleoncomud* PERK) into ethyl cinnamate

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Abstract. *Isolation of frankincense cinnamic acid (SYTRAX paralleoncomud PERK) has been carried out using ethanol solvent by maceration. The results of the maceration are then added with 4 M NaOH until two phases of organic and water occur. Next, the water phase containing sodium cinnamate is acidified with concentrated H_2SO_4 until two phases are formed, namely the organic phase containing cinnamic acid and the water phase. This sulfuric acid also hydrolyzes cinnamyl cinnamate into cinnamic acid and cinnamyl alcohol, thereby increasing the levels of cinnamic acid. Next, the cinnamic acid is washed with water and then esterified with ethanol catalyzed with concentrated sulfuric acid at a temperature of 60°C for one hour. The results obtained were rinsed and dried with anhydrous Na2SO4 then filtered. Analysis of the functional groups of cinnamic acid and ethyl cinnamate was carried out using the FTIR spectroscopy technique, while the purity of ethyl cinnamate was analyzed by using the Gas Chromatography - Mass Spectroscopy (GC-MS) technique. Physically, the result of ethyl cinnamate has a distinctive ester or essence smell. Based on the results of FTIR spectra interpretation, the conformational isolation result is cinnamate acid which is shown by a wide and strong absorption at 3500 cm-1 from the hydrooxyl group (-OH) and a strong and sharp absorption at 1700 cm-1 is from the carbonyl group (C = O). Furthermore, as a result of esterification to ethyl cinnamate, there was a decrease in the intensity of OH absorption, indicating that the product ethyl cinnamate was formed. Based on the results of the interpretation of the GC-MS chromatogram, a relatively high level of ethyl cinnamate was obtained, namely 84.42%.*

Keywords: cinnamic acid, esterification, ethyl cinnamate

Introduction

Frankincense is one of the largest non-timber forest products in North Sumatra which is widely used in the pharmaceutical, cosmetic and perfume sectors [1]. The main component of frankincense is cinnamic acid which is widely used as medicine and cosmetics [2]. Botanically, the level of cinnamic acid is one of the criteria for obtaining superior seeds for cultivating frankincense plants and also as a parameter for the quality of frankincense [3].

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Cinnamic acid is an organic compound of natural products from the phenylpropanoid group which has broad spectrum pharmacological activities, including as an antioxidant, antibacterial, antitumor [4], antimicrobial anaesthetic, anti-inflammatory, antispasmodic, antimutagenic [5], fungicide, herbicide and tyrosinase enzyme inhibitor [6]. Apart from that, cinnamic acid can also be used as a preservative, fragrance in food, cosmetics and soap [7,8]

The component with the second highest level is cinnamyl cinnamate, which is easily hydrolyzed into cinnamic acid and benzoic acid, thereby increasing the levels of cinnamic acid in frankincense. In this research, transformation of a cinnamic acid derivative, namely ethyl cinnamate, was carried out. The ethyl cinnamate compound is an ester group of compounds that is useful as a sunscreen which is able to absorb ultraviolet radiation [9], as an antifungal and antimicrobial and anti-inflammatory [10], antibacterial pathogen and anti-fungal [11]. Ethyl cinnamate is also an ingredient in cosmetic formulations that functions as a natural preservative and is also used as a flavor enhancer and spicy essence in the food industry [12]. Ethyl cinnamate also has potential as an antidiabetic, asthma medication, cosmetics, food industry, especially food because of its unique taste and aroma and high stability [13,14].

In this research, the transformation of cinnamic acid into ethyl cinnamate will be carried out using the acid-catalyzed Fisher esterification process. Sulfuric acid also hydrolyzes cinnamyl cinnamate into cinnamic acid and cinnamyl alcohol, thereby increasing cinnamic acid as a base. Isolation of frankincense cinnamic acid was carried out using a maceration technique with ethanol solvent, which is thought to also extract cinnamyl cinnamate. Next, to isolate cinnamic acid, 0.4 M NaOH is added where sodium cinnamate is in the water phase. Next, the sodium cinnamate phase is acidified with concentrated sulfuric acid while also hydrolyzing the cinnamyl cinnamate that is also extracted, thereby increasing the cinnamic acid level. The organic phase containing cinnamic acid was rinsed with water and then dried with anhydrous Na_2SO_4 [15]. The synthesis of the ethyl cinnamate compound was carried out through the Fisher esterification reaction by reacting cinnamic acid with ethanol catalyzed by sulfuric acid. In this research, the target molecule to be produced is ethyl cinnamate, by reacting total cinnamic acid with ethanol catalyzed by sulfuric acid [16]. Analysis of the functional groups of cinnamic acid and ethyl cinnamate was carried out using the FTIR spectroscopy technique, while the purity of ethyl cinnamate was analyzed using the Gas Chromatography – Mass Spectroscopy (GC-MS) technique [17,18].

Methodology

Chemicals and Equipment

The chemicals used in this research were frankincense from the Garoga area, North Tapanuli Regency, ethanol, NaOH, anhydrous Na_2SO_4, concentrated sulfuric acid, distilled water and universal pH paper. Meanwhile, the equipment used is various glassware, a set of reflux equipment, a Prestige 21 FTIR Spectrophotometer and a GC-MS QP2010.

Research procedure

Isolation of cinnamic acid, purification and esterification were carried out at the Unimed Chemistry Laboratory, while FTIR spectra recording and GC-MS chromatograms were analyzed at the UGM Instrument and Organic Chemistry Laboratory. The research process is: isolation of frankincense cinnamic acid (SYTRAX paralleoncomud PERK) with ethanol solvent by maceration. Next, the results of the maceration are added with 4 M NaOH until two phases occur, namely organic and water. Next, the water phase containing sodium cinnamate is acidified with concentrated H_2SO_4 which is controlled with Universal pH paper until two phases are formed, namely the organic phase containing cinnamic acid and the water phase.

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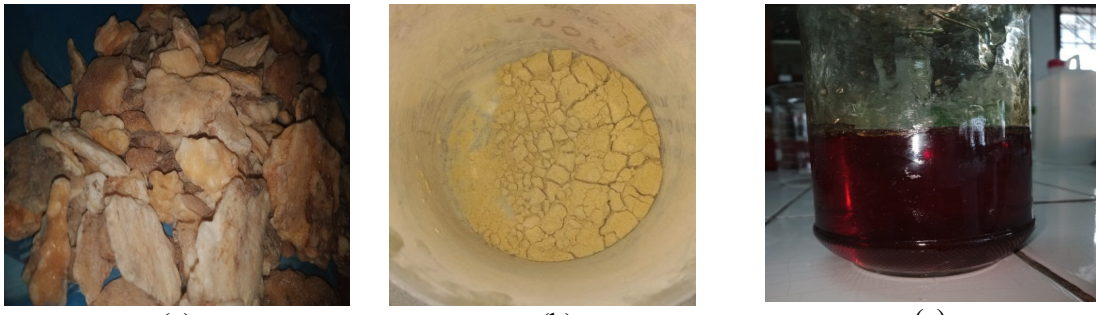
This sulfuric acid also hydrolyzes cinnamyl cinnamate into cinnamic acid and cinnamyl alcohol to increase cinnamic acid levels. Next, the cinnamic acid is rinsed with water then esterified with ethanol catalyzed with concentrated sulfuric acid at a temperature of 60°C for one hour. The results obtained were dried with anhydrous Na_2SO_4 and then filtered. Analysis of the functional groups of cinnamic acid and ethyl cinnamate was carried out using the FTIR spectroscopy technique, while the purity of ethyl cinnamate was analyzed using the Gas Chromatography - Mass Spectroscopy (GC-MS) technique.

Result and Discussion

Preparation was carried out at the Unimed Chemistry Laboratory and recording of FTIR spectra and GC - MS Chromatogram was carried out at the UGM Instrument and Organic Laboratory.

Isolation of Frankincense Cinnamic Acid and its conversion into ethyl cinamate

The incense samples used were obtained from farmers in Garoga District, North Tapanuli Regency as one of the centers producing Tapanuli incense which was ground into 80 mesh size powder and macerated with ethanol to obtain cinnamic acid as shown in figure 1



(a) (b) (c)

Figure 1. Frankincense used as sample (a), Frankincense gum powder measuring 80 mesh (b) and is the result of maceration with ethanol solvent (c).

Purified cinnamic acid is esterified with ethanol using a sulfuric acid catalyst to produce ethyl cinnamate which has a lower viscosity compared to cinnamic acid. Pure ethyl cinnamate at room temperature is a liquid so the viscosity is lower with a boiling point of 132oC, while cinnamic acid has a boiling point of 200oC. Physically, cinnamate esters have a distinctive ester scent (essence) so they can be used as raw materials for cosmetics, especially perfumes.

Recording of FTIR Spectra and GC-MS Chromatograms

The results of FTIR spectra recording of a compound can be used as an indicator of whether a reaction is taking place based on analysis of its functional groups. The reaction of an organic compound is essentially a transformation of functional groups so that by comparing the functional groups before and after the reaction it can be concluded that the progress of a reaction is as shown in Figure 2.

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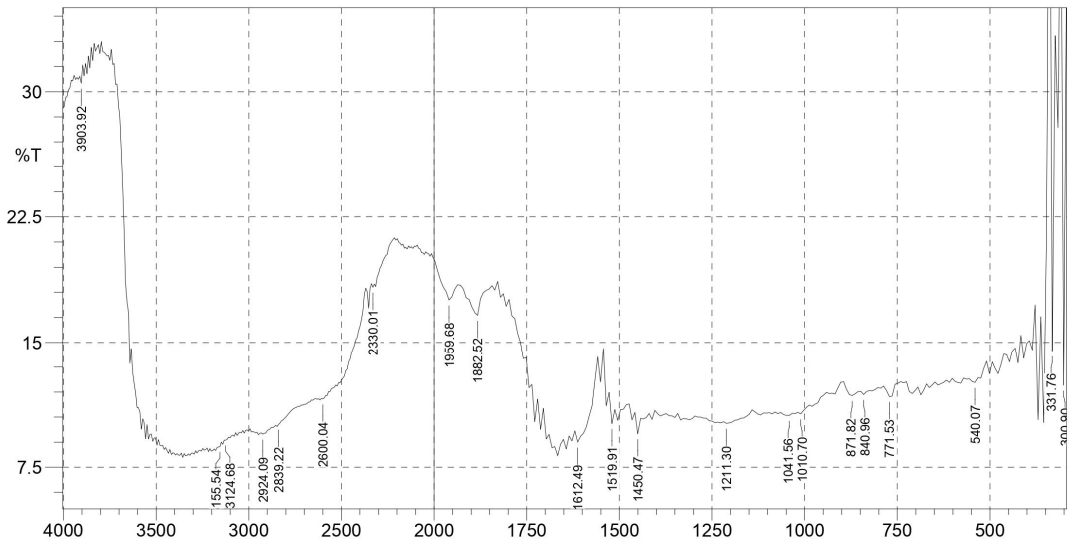
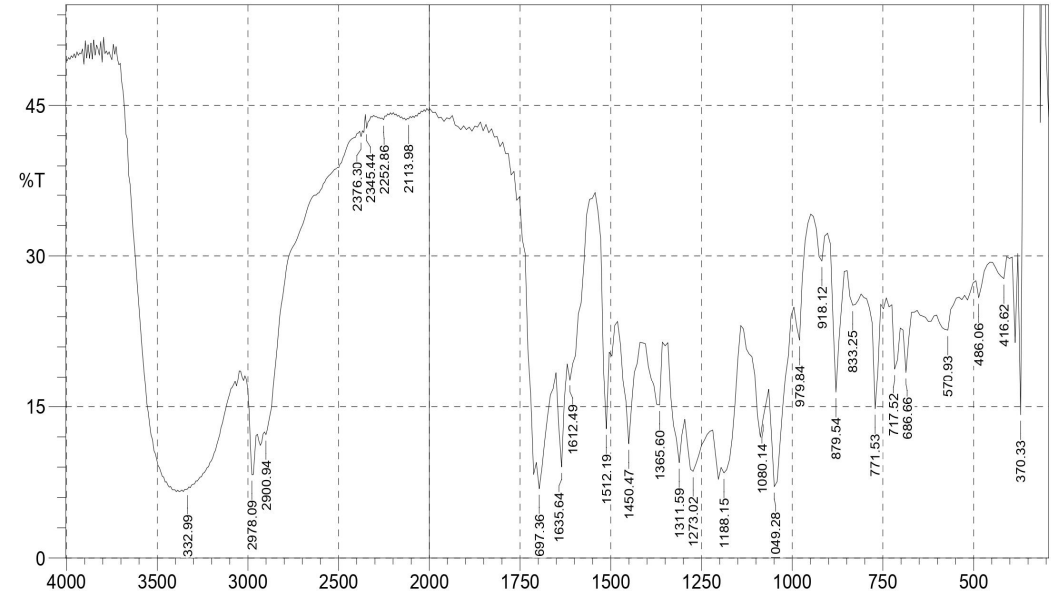


(a)



(b)

Figure 2. FTIR spectrum of cinnamic acid isolated from frankincense (a) and FTIR spectrum of ethyl cinnamate resulting from Fischer esterification (b).

The FTIR spectrum in Figure 2(a) is verified to contain the main functional group of cinnamic acid, namely wide and strong absorption at 3000 - 3500 cm^{-1} from the hydroxyl group (-OH). This widening is due to the very strong hydrogen bonds of the acid (-OH) group. Furthermore, the carbonyl group is absorbed at 1600 – 1700 $^{-1}$ which overlaps with the alkene group (C= C) from both the benzene ring and the propanoid. Furthermore, the FTIR spectra of ethyl acetate in Figure 2(b) conformation has undergone a reaction to produce ethyl acetate. The hydroxyl group is still readable but its intensity has decreased, indicating that most of the cinnamic acid has been converted into ethyl cinnamate. This is supported by the very high resolutions absorption between the carbonyl group (C=O) in the absorption band 1607 cm^{-1}

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and the alkene group in the absorption band 1635 cm^{-1}.

To support the conclusion that the esterification reaction took place, GC-MS recording of the results was carried out with the chromatogram in Figure 3.

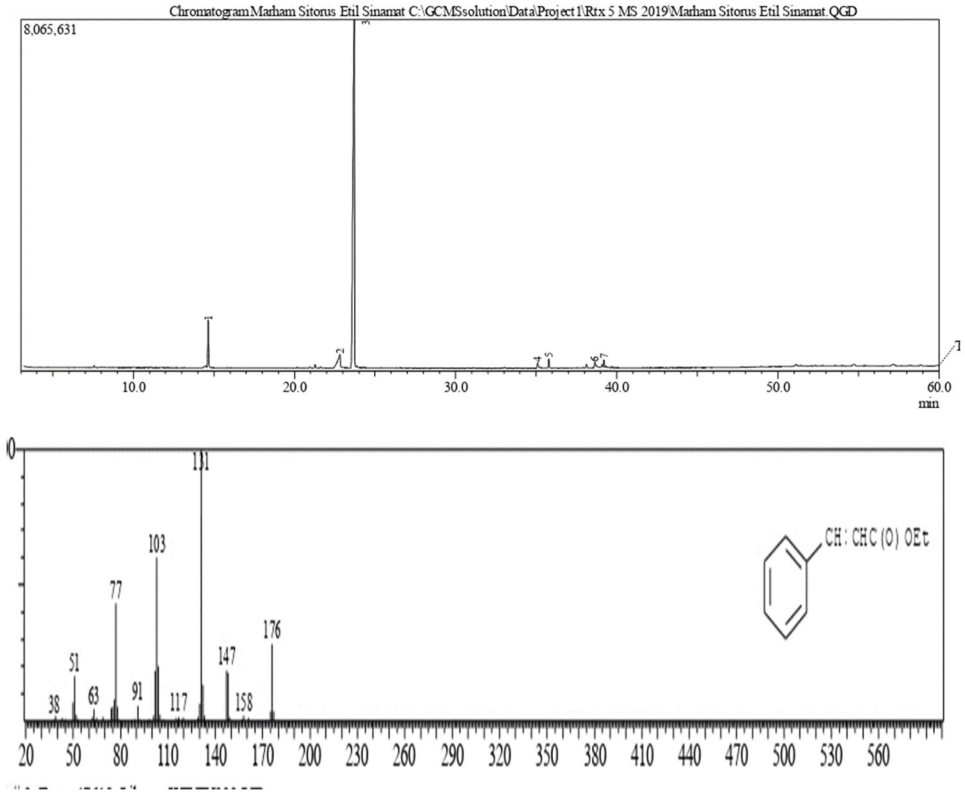

Figure 3. GC-MS chromatogram of ethyl cinnamate resulting from Fisher esterification

Based on the GC-MS chromatogram in Figure 3, the ethyl cinnamate (conformation from Lybrary) chromatogram has a very high content, namely 84.42%, namely peak 3 with an elution time of 23.706 minutes. In this case the results cannot be compared with the GC-MS chromatogram of cinnamic acid because GC-MS recording cannot be carried out due to its high boiling point.

Conclusion

Physically, ethyl cinnamate is a liquid with a boiling point of 132oC with a characteristic ester or essence aroma. Based on the results of the interpretation of the FTIR spectra, the results show that the conformational isolation result is cinnamate which shows wide and strong absorption at around 3500 cm-1 from the hydroxyl group (-OH) and the 1700 cm-1 band is the carbonyl group (C = O), which in as a result of esterification to ethyl cinnamate, there is a decrease in the intensity of OH absorption, indicating that the reaction is taking place. The results of the interpretation of the GC-MS chromatogram showed relatively high levels of ethyl cinnamate, namely 84.42%.

Acknowledgement

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Analysis of free fatty acid and water content in tinuktuk during the storage period at room temperature

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Abstract. *Water content and free fatty acid levels are very influential when storing food. Analysis during storage is carried out to determine to what extent the quality of the food is suitable for consumption. The use of herbal medicine among the people of Indonesia has decreased. The same is the case in the Simalungun area, North Sumatra where currently there is little use of herbal medicine. The previous research has been carried out by the Tinuktuk research regarding the search for the optimum composition of Tinuktuk which was 30:70%. Thus, there is a need for further research regarding the storage process of Tinuktuk at room temperature until the ability of tinuktuk to ward off free radicals is known. The purpose of this study is to determine the durability period of using tinuktuk during the storage period as seen from the test results of free fatty acids and water content contained in Tinuktuk. The results of the average moisture content test in 0-14 days storage is 56%, in 21-49 days storage the moisture content value is 57%, in 56 days storage the moisture content value is 58%. This is related to the storage period in Tinuktuk, this is also in line with the increase in water content during the storage period which will cause the free fatty acid content to increase. The average free fatty acid analysis in 0-14 days storage is 5%, in 21-49 days storage the moisture content value is 9,71% in 56 days storage the moisture content value is 17,20%.*

Keywords: Tinuktuk, free radicals, water content, free fatty acids

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Introduction

Indonesia is one of the countries producing spices and herbs in the world. Some herbal plants belong to the spice group. The use of spices and herbs has been widely done, both in the food and health industries—one of the uses of spices and herbs is spices, from Simalungun Regency, North Sumatra province. Tinuktuk is very well known in the Simalungun community [1].

This Tinuktuk herb began to disappear due to the ease of getting instant flavoring on the market today. Functional foods, according to Badan POM (2001) [2], are foods that are natural and industrialized and contain one or more compounds that, according to scientific investigations, are considered to have various physiological activities beneficial to health. Simalungun's signature chili sauce is called tinuktuk or Sira pepper. Salt and nutritious spices such as red ginger, candlenuts, andaliman, onion, garlic, black pepper, and tamarind are added to produce tinuktuk [3].

Drying is a complex operation that involves the transfer of heat and mass that is not fixed along with several process rates such as physical and chemical changes that can result in changes in product quality [4]. According to Ratti and Kudra (2006) [5], volumetric heat in heating with a microwave oven can be generated throughout the product. Heating with a microwave oven does not depend on the thermal conductivity of the material because heat is generated with microwave oven energy. This study aims to determine the water content and free fatty acid content in tinuktuk during the storage period. To know the good consumption period for tinuktuk.

Methodology

Seasoning Ingredients

Black pepper, red ginger, aromatic ginger aromatic, hazelnut, onion, garlic and tamarind, andaliman, Himalayan salt.

Chemicals

Chemicals such as Aquadest, alcohol 96%, phenolphthalein indicator, n-Hexane, sodium hydroxide, chloroform, glacial acetic acid, potassium iodide, amylum 1%, sodium thiosulfate, methanol.

Tools

Dry material grinder, wet material grinder, a cauldron for shaking, electric scales, spoons, plastic containers, knives, cutting boards, electric scales, measuring cups, filter paper, desiccators, water baths, Petri dishes, static and clamps, burettes, glass funnels, drip pipettes, suction balls, beaker glass, erlenmeyer, ovens, tongs, plastic clips, spatulas, dips, and soxhletation.

Work Procedure

1. Making chili sauce tinuktuk with optimization of the ratio of red ginger and black pepper
The existing ingredients are shaken separately, into 3 parts:
a. Pepper is shaken, do not need to turn black
b. Pecan roasted
c. Kencur, red ginger, onion, garlic and onion batak roasted

Then all the ingredients that have been shaken are ground (poked) each separately according to its group. The remaining powder, which is still coarse, is kneaded again until it is very smooth. These kneaded ingredients are then put together and ground again together. Kincung

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fruit or Sihala, ground, squeezed, and squeezed water into a kind of acidic liquid for the finished Tinuktuk using a ratio between red ginger and black pepper with a percentage (30%: 70%).

Water Content Analysis (AOAC 2005) [6]

Moisture content measurement is carried out by weighing sterile porcelain dishes using an analytical balance to determine their empty weight. About 10 g of sambal tinuktuk samples were weighed in a porcelain dish. The sambal tinuktuk sample is then dried in an oven at 105°C for 4 hours and cooled in a desiccator, then weighed until a constant weight is obtained from the cup and dry sample.

Free Fatty Acid Analysis (PORIM 1995) [7]

Free fatty acid levels are measured by titration method with alkaline indicators. A sample of 2.5 grams was added to 50 mL of 96% alcohol which had been heated on a hot plate at 70° C. Added 3 drops of phenolphthalein indicator then mixed until homogeneous in Erlenmeyer 250 mL, the solution is titrated using sodium hydroxide 0.05 N which has been standardized while stirring until the pink color appears as a neutral alcohol color.

Results and Discussion

Water Content

Water content is an important parameter because water content affects the shelf life of chili sauce. In this study, water content analysis was carried out to determine the amount of water content contained in chili sauce products. Water can affect the appearance, texture, taste, and shelf life of foodstuffs. In addition to water content in foodstuffs, quality parameters such as water content, taste, texture, color and so on will change due to environmental influences such as temperature, humidity, and air pressure or due to factors in the composition of the food itself (Maghu, 2019).

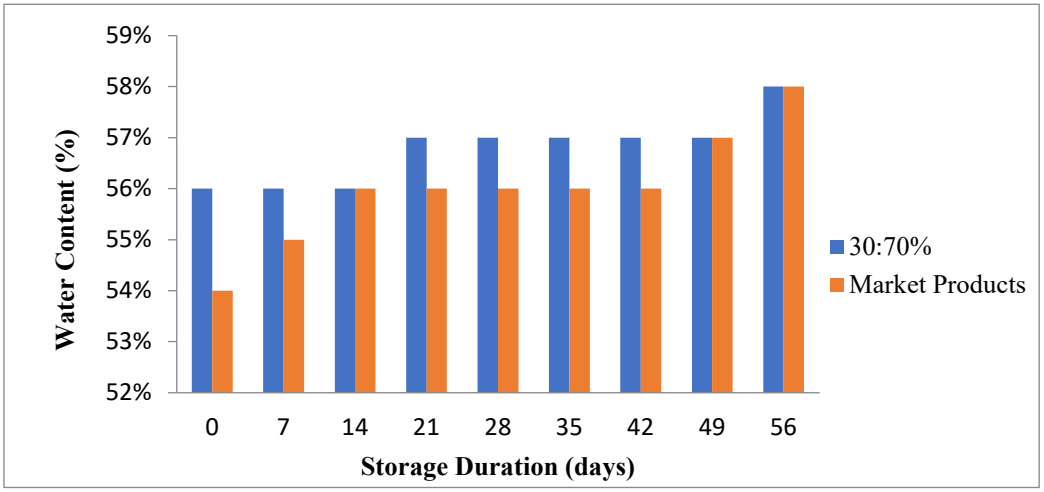

Figure 1. Moisture content ratio of 30:70% with market products

From the results of the analysis according to Figure 1, it is known that the water content of tinuktuk during storage has increased according to the statement (Maghu, 2019) in 0-14 days of storage the moisture content value is 56%, in 21-49 days storage the moisture content value is 57%, in 56 days storage the moisture content value is 58%. This shows that the water content of

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tinuktuk is lower than the quality requirements of SNI 01-2976-2006 which states that the water content of chili sauce is between 78.87% and a maximum of 83%, while the water content of tinuktuk is on average between 57-58%. This happens because the process of processing chili sauce by roasting results in the moisture content of the ingredients being relatively reduced [9].

Free Fatty Acid

Determination of free fatty acid levels can be one of the parameters to determine the quality of foods containing oil. In making tinuktuk itself contains several ingredients that contain oil content. This study determined the levels of free fatty acids in tinuktuk. The results of tests in table 1 showed that the free fatty acid during the storage period were increasing.

Table 1. Free fatty acid during storage

Storage (weeks)	Average V NaOH (mL)	Average N NaOH (N)	Mass Weight	Sample Mass	%
0-14	2.43	0.038	282	0.5	5.00%
21-49	4.49	0.04	282	0.5	9.71%
56	6.15	0.05	282	0.5	17.2

This is related to the storage period in tinuktuk, this is also in line with the increase in water content during the storage period will cause free fatty acid levels to increase [10]. The increased water and air content of foodstuffs during storage increases damage to oil which can be analyzed by calculating the free fatty acid levels of a sample. The more free fatty acid levels increase, the lower the quality will decrease Based on the results of testing the best free fatty acid levels, namely in the storage period of 0 weeks, which is 3.7%. The increase in free fatty acid levels during storage is caused by the hydrolysis process, where the hydrolysis process will produce one glycerol molecule and three free fatty acid molecules [11].

Conclusion

In this study, it can be seen that the tinuktuk during the storage period has changes related to water content and the test results of the free fatty acid analysis. During the storage period the results of the existing moisture content, namely during storage, have increased. In 0-14 days storage the moisture value is 56%, in 21-49 days storage the moisture value is 57%, in 56 days storage the moisture content value is 58%. Based on the results of testing the best free fatty acid levels, namely in the storage period of 0 weeks, which is 3.7%, and the value of free fatty acids in the tinuktuk pond itself has increased in percentage during the storage period

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Effect of fixation type on color quality of cotton thread with natural dyes of local plants jabi jabi (*Ficus retusa* L) leaf extracts

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Abstract. *The use of natural dyes has the disadvantage that they fade easily, so a fixation agent is needed. The local Jabi jabi (Ficus retusa L) plant contains natural pigments and is found in North Sumatra, Indonesia, so it has the potential as a natural textile dye. This study aims to determine the effect of the best type of fixator in the manufacture of natural dyes from Jabi jabi leaf extract on the quality of dyed cotton yarn. The type of extraction solvent was determined based on the results of the tannin and stain tests on thin layer chromatography. Variations in the types of fixatives in this study were divided into four groups, namely the group of plant extract dyes without fixation (K0), alum fixation (K1), tunjung fixation (K2), and lime fixation (K3). The parameters measured were the value of fastness to washing soap and sunlight, the color difference value, and the IR spectrum of the dye. The results showed that the type of fixation agent in the natural dyes of the ethanol extract of jabi jabi leaves had an effect on the quality of the color of the dyed cotton thread.*

Keyword : Natural dyes**,** fixation, color quality of cotton**,** jabi jabi (Ficus retusa L)

Introduction

The increase in fashion production causes an increase in hazardous liquid waste in waters, especially that originating from synthetic textile dyes [1-3]. It is necessary to develop natural textile dyes to reduce the use of synthetic dyes. Plants that have natural pigments such as chlorophyll, carotenoids, tannins and anthocyanins can be used as natural dyes [4]. However, the

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use of natural dyes has the disadvantage that it fades easily, so a fixator is needed. A fixator is a substance that binds and strengthens the resulting dye [5]. There are three types of fixator that are commonly used to strengthen color bonds in fabric and provide different color directions and are safe for the environment, namely quicklime (CaO), alum ($KAl(SO_4)_2.12H_2O$) and tunjung ($FeSO_4$) [6]. The Jabi jabi plant (*Ficus retusa* L) contains natural pigments [7] and is often found in North Sumatra, Indonesia, so it has the potential to be a natural textile dye. This research aims to determine the best type of fixator for making natural dyes for cotton yarn from jabi jabi (*Ficus retusa* L) leaf extract.

Methodology

Material

The material used is fresh jabi-jabi leaves (*Ficus retusa* L), obtained from Samosir, Sumatera Utara, Indonesia and has been determined at the USU Medanense Herbarium (MEDA) Plant Systematics Laboratory as *Ficus retusa* L (Number 886/MEDA/2023, 3 May 2023), Turkey Red Oil (TRO), distilled water, alum ($KAl(SO_4)_2.12H_2O$), tunjung ($FeSO_4$), quicklime (CaO), solvent (E.merck) n-hexane, ethyl acetate, ethanol, chloroform, $FeCl_3$, filter paper and cotton thread. The tools used are analytical scales, a set of glassware, Buchner funnel, hot plate, evaporator, maceration container, blender, Fourier Transform Infra Red (FTIR) spectrophotometer, spectrophotometer (UV-PC model ISR-2200) and gray scale test equipment.

Method

Jabi-jabi Leaf Sample Extraction

Fresh Jabi jabi leaves are washed clean, dried (avoided from direct sunlight), then crushed (60 mesh) and jabi-jabi leaf simplicia powder is obtained [8]. A total of 500.0 grams of jabi jabi leaf powder was put into a glass bottle, added with 2.5 L of 96% ethanol, soaked for 48 hours, while stirring several times. The solution was filtered, the filtrate was put into a dark bottle, concentrated using a rotary evaporator, to obtain an ethanol extract of jabi-jabi leaves [9]. The tannin test was carried out by adding 1% $FeCl_3$ to the ethanol extract of Jabi jabi leaves. The test results showed positive tannin with a color change to blackish green. This is due to the reaction between $FeCl_3$ and the phenol group in tannin to produce a green-black complex [10].

Addition of Fixative Substance

Each fixative agent (tunjung and quicklime) is dissolved in water with a ratio of the amount of fixative agent to water of 1: 25. Next, the fixative agent solution is added to the thick extract of jabi-jabi leaves with a ratio of fixative agent solution to extract of 10: 1 [11] with modifications). Specifically to dissolve the alum fixative in water, heating is carried out until the alum is completely dissolved [12].

Functional Group Analysis with FT-IR

The natural dye powder obtained was analyzed for its functional groups using the infrared spectroscopy analysis method which is based on differences in the absorption of infrared radiation by a material molecule [13].

Yarn Pre-Dyeing Process

A total of 2.1 grams of TRO was dissolved in 1.0 L of water. Next, the thread is soaked in TRO solution for 30 minutes, then washed until clean and dried [12]. TRO solution ($C_{18}H_{32}Na_2O_6S$)

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acts as a surfactant to clean non-cellulose substances found in yarn such as hemicellulose, lignin, pectin, wax and ash so that the reaction of cellulose with ionized dyes runs quickly [14].

Making Dye Solution

To dye one ring of cotton thread, prepare 2.0 L of natural dye solution to which a fixing agent has been added [15].

Yarn Dyeing

The cotton thread is dipped in the dye solution for 15 minutes, then removed and aired. This process was repeated three times until the color was evenly distributed on the thread [11].

Test Against Soap Washing

The quality test of dyed yarn for soap washing is carried out in accordance with the SNI ISO 105-X12 standard. The soap solution is prepared in a heating glass on a test heating stove, then the dyed yarn sample is placed into the soap solution. Heating is carried out to 50°C with a Vlot ratio of 1:30. The sample was stirred and pressed against the glass wall every 2 minutes during the heating process. After 30 minutes, the sample was removed and then rinsed with cold distilled water and then rinsed with running water for 10 minutes. The samples were squeezed then aired until dry and assessed using a gray scale [16].

Test against solar radiation

The dyed yarn samples to be tested are spread out on a piece of plywood in rows. Half of the sample size was covered with folded paper with a thickness of ±1 mm and then dried in the sun for 6 hours (from 09.00 to 15.00). Measurements were carried out using a gray scale tool in accordance with the SNI ISO 105-X12 standard [16].

Color Difference Test

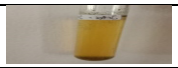
The dyed yarn samples were tested for different colors (L*, a*, and b* values) using a spectrophotometer (UV-VIS PC 2401) [17].

Result and discussion

Color of Jabi jabi Leaf Ethanol Extract Fixation Solution

The color of the fixation solution for the ethanol extract of Jabi-jabi leaves is presented in Table 1.

Table 1. Color of Jabi-Jabi Fixation Solution

Fixation Agent	Color of Jabi-Jabi Leaf Extract Fixation Solution
No Fixative Substances (K0)	
Alum or $KAl(SO_4)_2$. 12 H_2O (K1)	
Tunjung or $FeSO_4$ (K2)	
Quicklime or CaO (K3)	

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As a result of adding the fixing agent, different solution colors are obtained. This is in accordance with the theory put forward by Failisnur and Sofyan [18] that certain metal ions which react with tannin will produce specific colors. Tannins found in plants are macromolecules and contain many hydroxy groups (-OH) which can form coordinating covalent bonds with metals [19].

Functional Group Analysis

FTIR spectra from fixation of jabi-jabi leaf extract for each variation are presented in Figure 1.

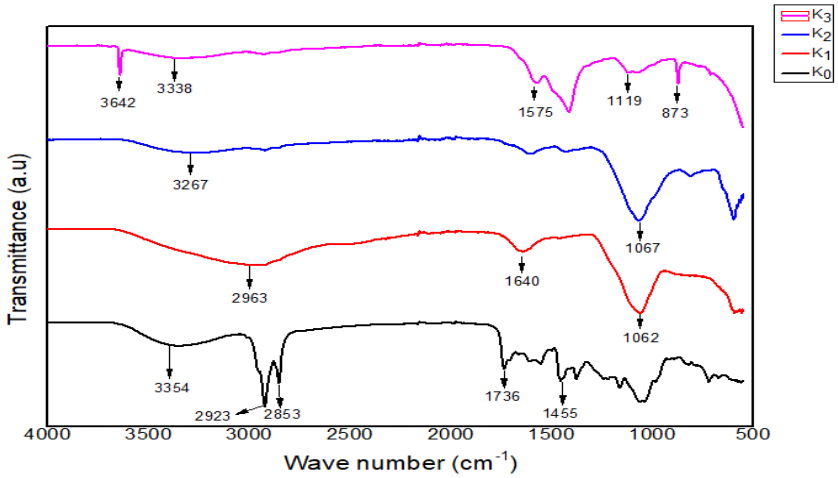

Figure 1. FTIR Spectra of Jabi-Jabi Leaf Ethanol Extract Fixation

Information:
K0: Jabi-jabi Extract
K1: Jabi-jabi Extract + Alum Fixing Agent
K2: Jabi-jabi Extract + Tunjung Fixing Agent
K3: Jabi-jabi Extract + Tohor Lime Fixing Agent

Functional groups from the results of FTIR spectra analysis of fixation of jabi-jabi leaf ethanol extract are presented in Table 2.

Table 2. Results of FTIR Spectra Analysis of Jabi Jabi Leaf Ethanol Extract Fixation

Jabi-Jabi Fixation Group	Wave Number (cm^{-1})	Functional groups
K0 (without fixing agent)	3354, 2923, 2853	-OH
	1736	C=O
	1455	C-H
K1 (Alum fixation)	2963	-OH
	1640	C=C
	1062	C - O
K2 (Tunjung fixation)	3267	O-H
	1067	C-O
K3 (Quick lime fixation)	3642, 3338	-OH
	1575	C=C
	1119	C-O
	873	C-H

From Table 2 it can be seen that in the four fixation variations, there are various chromophore groups (C=O; C=C) and auxochrome -OH groups which play a role in the

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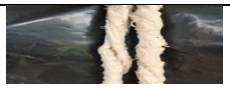
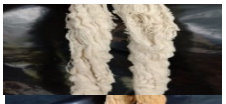
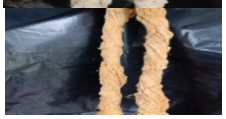
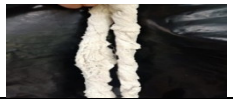
formation of dyes. The addition of fixatives to jabi jabi leaf extract, apart from playing a role in strengthening the dye bonds, also plays a role in changing the direction of natural dyes or coloring matter produced by plants [12]. The addition of a fixative to tannin, which is a natural pigment in jabi jabi leaves, causes the formation of chromophore groups and auxochrome groups which have the potential to act as dyes and cause color changes [20].

Yarn Dyeing Results

The results of dyeing cotton thread with fixation dye from ethanol extract of jabi-jabi leaves are presented in Table 3.

Table 3. Results of Dyeing Yarn with Dye Resulting from Ethanol Extract Fixation of Jabi-jabi Leaves

Fixation Agent	Jabi-Jabi Leaf Extract Dyed Yarn Color
No Fixative Substances (K0)	
Alum or $KAl(SO_4)_2$. 12 H_2O (K1)	
Tunjung or $FeSO_4$ (K2)	
Quicklime or CaO (K3)	

The results of dyeing threads (Table 3) show that different thread colors are obtained for each type of fixation because the colors produced by each metal ion are different. When the thread, which is cellulose, reacts with the dye, a covalent bond occurs between the two. In the yarn dyeing process, SN2 nucleophilic substitution occurs where the halogen atoms from the dye are substituted with nucleophilic hydroxy groups from cellulose (Sel-O-) [21]. Cellulose has abundant hydroxyl groups, namely one primary C-6 and two secondary C-2 and C-3 in each anhydroglucose unit, making it possible for intramolecular and intermolecular hydrogen bonds to occur during the dyeing process.

Yarn Quality Test Results

The quality test results of threads that have been dyed with natural dyes from jabi-jabi leaf extract are presented in Table 4.

From Table 4 below, it can be seen that K0 (group without fixation) and K1 (group with alum fixation) have the best values for color fastness of thread to washing with soap.

Meanwhile, K3 (the group with quicklime fixation) has the best color fastness value of the thread to sunlight. When washing with soap, the soap acts as a nucleophilic (electron-rich group), attacking the weakly bonded electrons (phi bonds) in the chromophore in the fiber. If the bond between the electrons in the chromophore is not stable enough, one of the electrons will be released from the double bond and bind to the nucleophile of the soap compound, causing fading or loss of dye from the fiber. Meanwhile, when solar radiation is carried out, sunlight contains

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ultraviolet which has the highest quantum energy. When shining light on the surface of colored molecules, it can cause changes in the molecular structure and color [22] by breaking the double bonds in the chromophore groups so that the color of the fiber fades or disappears.

The color difference value of the dyed yarn was tested using the UV-PC program model ISR-2200. The results of color difference analysis are presented in L*, a*, and b*. The L* (lightness) value represents the brightness level of the thread color, the greater the L* value obtained, the brighter the color obtained and vice versa. The a* value represents the color position in the green-red axis.

Table 4. Yarn Quality Test Results

Yarn Sample Code	TLW Test Value (Color Fastness) of Yarn to Soap Washing	TLW Test Value (Color Fastness) of Yarn to Sunlight	Yarn Color Difference Test Values			
			L*	a*	b*	dE*ab
Standard-White Thread			98.62	-0.16	-0.01	0.00
Jabi-Jabi Leaf Extract Dyed Yarn Without Fixation (K0)	5 (Very Good)	3-4 (Fairly Good)	85.76	3.57	4.26	14.06
Dyed Yarn with Jabi-Jabi Leaf Extract Alum Fixation (K1)	5 (Very Good)	3-4 (Fairly Good)	98.10	2.09	-3.07	3.84
Dyed Yarn with Jabi-Jabi Leaf Extract Tunjung Fixation (K2)	4-5 (Good)	4 (Good)	38.05	22.93	26.20	69.92
Dyed Yarn with Tohor Lime Fixation Jabi-Jabi Leaf Extract (K3)	4-5 (Good)	4-5 (Good)	77.16	5.27	17.16	28.02

The smaller the a* value (minus value), the thread color is in a greenish position, conversely, the greater a value (positive value), the thread color is in the reddish position. The b* value represents the color position in the blue-yellow axis, the smaller the b* value (minus value) means the thread color is in a bluish position, conversely the greater the b value (positive value) then the thread color is in a yellowish position. From these three parameters, the total value of light reflection on the thread (dE*ab) can be calculated.

From Table 4 above, K2 (the group with alum fixation) has the largest total light reflection (dE*ab) value, which means the color produced is the oldest color among the others, while K1 (the group with alum fixation) has the highest value. The total reflection of light (dE*ab) is the smallest, which means the color produced is the lightest color among the other groups.

Conclusion

Jabi-jabi leaves (*Ficus retusa* L) have potential as a natural textile dye. The result of adding a fixing agent to Jabi jabi leaf extract produces different thread colors and has good fade resistance qualities. The type of fixative added to the ethanol extract of jabi jabi leaves affects the color quality of the dyed cotton thread.

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The effect of a mixture extract of cinnamon (*Cinnamomum burmanii*) bark, ginger (*Zingiber officinale*), and lemongrass (*Cymbopogon citratus*), on alloxan-induced male Rattus novergicus SGPT, SGOT levels

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Abstract. *Diabetic mellitus is a chronic metabolic disease characterized by hyperglycemia. The condition of diabetes mellitus that lasts a long time results in oxidative stress and may play a role in the occurrence of advanced complications such as liver damage characterized by increased levels of SGOT (serum glutamic oxaloacetic transaminase) and SGPT (serum glutamic pyruvic transaminase). In this experiment, we reported the number of samples used was 28 experimental animals divided into the following groups: regular group, negative group (alloxan), positive group (metformin), mixed extract cinnamon (Cinnamomum burmanii) bark, ginger (Zingiber officinale), and lemongrass (Cymbopogon citratus), dose of 200 mg/kg bw, mixed extract of ginger, lemongrass, and cinnamon dose of 300 mg/kg bw, and mixed extract of ginger, lemongrass, and cinnamon dose of 400 mg/kg bw. Each group was treated for 21 days. The results showed that SGOT levels were tested for Shapiro-Wilk normality and continued with the Anova test to get a p-value> 0.05 and a significant value of 0.994> 0.05. The study results showed that in normal rats, namely K0, the group of K0 rats had normal SGOT and SGPT levels, namely 18.00 µ/L and 34.75 µ/L. there was an increase in SGOT and SGPT in alloxan-induced rats, namely 90.00 µ/L and 139 µ/L And in alloxan-induced rats given the herbal mixture extract, there was a significant decrease in SGOT and SGPT levels at concentrations of 300mg/Kg BB, namely 28.00 /L and 34.75 µ/L. and 400 mg/Kg body weight which is 22.00 µ/L and 34.00 µ/L.*

Keyword: extract of ginger, lemongrass, and cinnamon, antidiabetic, SGOT, SGP

Introduction

Increased blood glucose levels caused by the retention of insulin is a feature of Diabetes Mellitus [1]. The state of hyperglycemia experienced by diabetics, if left for a long time, can cause health complications, disability, and damage to various dangerous organs, such as heart disease, nerve problems, kidney disorders, and eye disorders that cause retinopathy and vision loss. In addition, life expectancy can be reduced by about 5-10 years [2]. Type 1 diabetes is

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caused by a lack of insulin production caused by damage to the pancreatic islet cells; this condition is treated only with insulin. Type 2 diabetes mellitus is a condition characterized by the retention of insulin. It develops from an initial period of relatively preserved insulin resistance as the pancreas attempts to maintain euglycemia [3]. Mostly 90% of individuals suffer from type 2 diabetes mellitus, which is the most common form of diabetes mellitus among all cases of diabetes mellitus [4].

Recently, the consumption of herbal plants has been in great demand by diabetics; this is because the use of chemical drugs that are too long can cause side effects such as kidney disorders in experimental rats induced by alloxan; there is an increase in blood sugar levels so that they experience hyperglycemia. For this reason, we also looked at SGOT and SGPT levels in rats given extracts from a mixture of ginger, lemongrass and Cinnamon bark, to determine whether these extracts' administration affects liver function [5].

Methodology

Experimental animals are wistar rats aged two months, The tools used in this study are tools for making plant extracts such as blenders (Mitochiba), glass bottles, containers Erlenmeyer (Pyrex), stirrers, dropper pipettes, volumetric flasks (Pyrex), test tubes (Pyrex) tube racks, hot plates, plastic topless, vacuum rotary evaporator (Heidolph), buncher funnel reflux (Pyrex), distillation apparatus (Pyrex), balance, oven (Hakashima). For induction using spoit and syringe, and to determine blood glucose levels in the Medan Kesda lab. The materials used in this study were cinnamon (*Cinnamomum burmanii*) bark, ginger (*Zingiber officinale*), and lemongrass (*Cymbopogon citratus*), NaCl 0.9%, metformin, filter paper, tissue, gloves, alcohol 96%, xylol, Vaseline, materials for extraction, masks and EDTA tubes. In the following study, according to the experimental design in the form of a non-factorial complete randomized design (CRD). The test animals were subjected to 7 treatments with 4 repetitions each: standard control, negative control, positive control, and 4 different concentrations of extracts. All rats were treated the same, given food and drink ad libitum and their respective treatments. KO+= i.e. rats are only given food and drink, K- = i.e. rats induced alloxan, K+ = i.e., rats induced alloxan given food as well as oral medication metformin, K1= i.e., rats induced alloxan as well as plant mixture extract 100 mg/KgBW, K2= i.e., rats induced alloxan and plant mixture extract 200 mg/KgBW, K3= i.e. rats induced alloxan and plant mixture extract 300 mg/KgBW, K4 i.e. rats induced alloxan and plant mixture extract 400 mg/Kg.

Preparation of test animals

The test animals used in this study were male Wistar strain rats aged about 2-3 months, weighing 150-200 grams. The cage is rectangular plastic topped with a wire lid so the rats do not get out and have air ventilation. Inside the cage is provided with a place to eat and drink. The room temperature of the test animals ranged from 18°C-26°C with adequate air circulation. Pest control in the rat cage is carried out routinely. The bottom of the cage is sprinkled with rice husk, which absorbs rat feces. After one week of acclimatization, the animals were divided into four groups of 4. The required 28 test animals, after which the cage is labeled according to the treatment of each test animal, namely, KO, K+, K-, K1, K2, K3, K4. The making of this group of experimental animals was done randomly.

Sample preparation

Cinnamon, ginger, and lemongrass samples weighed 1.5kg, 5kg, and 5kg, respectively. After that, the samples were washed, cut into thin strips, and dried in the oven at 40°-50°C for 6-8 hours. After the samples are dry, they are pulverized and sieved with a 60 mesh sieve to

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facilitate the extraction process and get as many extraction results as possible, with the hope that the metabolite content of the sample is not lost.

Plant extraction: The Simplicia plant that has been obtained is weighed as much as 200 grams for each ginger plant and lemongrass plant, then 75 grams for cinnamon bark. Furthermore, the simple powder is put into a pot and added with 5 ml of water, and then boiling is carried out. This extraction is repeated twice to take as many secondary metabolites as possible from the simplicia. After heating, the stew is thickened at 40°C-50°C to evaporate the solvent content so that only the extract is obtained.

Alloxan dose

In this study, the dose of alloxan used to induce rats was 150 mg/KgBW which was injected intra peritoneally (6). The study has proven that a dose of alloxan as much as 150 mg/KgBW has made rats diabetic. Then, the need for alloxan in rats weighing 200 grams, according to the calculation, is:

$$200\text{g} = \frac{200g}{1000g} \text{ X } 150 \text{ mg/KgBW} = 32\text{mg/ rat } 200 \text{ g.}$$

Before being induced in the experimental animals, alloxan was diluted using distilled water with a solution concentration of 25 mg/ml. Then, on the 8th day after acclimation, alloxan was induced in the experimental animals, after which the experimental animals were fed for 16 hours 48 hours after the rats had been induced, and blood observations are made through the rat's tails. If the glucose level in the experimental animals has risen, the next stage can be done: administering plant ethanol extracts for the metformin oral drug administration group. The metformin dose for rats was 4.5 mg/kg BW. Metformin tablet powder equivalent to 360 mg was weighed and then suspended in 0.5% NaCMC up to 100 ml and shaken until homogeneous [7].

Alloxan induction

Experimental animals were first fed for 8 hours before blood glucose levels were observed. Blood was taken to see fasting blood glucose levels (GDPO), a good GDPO is <100mg/dl. Then rats were induced with alloxan 150 mg/kgBW dissolved in distilled water. Giving alloxan to each rat as much as 1mL induced intraperitoneally, then left for 3 x 24 hours until alloxan reacts and makes glucose levels in the blood of rats rise. Furthermore, rats are checked for postprandial blood sugar levels (GDP). Rats with increased blood sugar levels (> 140mg/dl) are declared hyperglycemia.

Administration of plant extracts

The administration of the extract to each group of diabetic rats was as much as 1ml according to the group dose using a round device every day for 14 days. Metformin administration. Furthermore, on the 15th day, blood was taken through the tail, collected with EDTA tubes, and disentrvuga 3000 rpm for 10 minutes; the separated serum was used for measurement of SGOT and Measurement of SGOT, and SGPT Levels.

The reagents used to measure SGOT levels contain tris buffer, lactate dehydrogenase, L-aspartate, α -ketoglutarate, malate dehydrogenase, and NADH. The amino groups of L-aspartate and α -ketoglutarate. Then, NADH will reduce oxaloacetate to form NAD with the help of a malate dehydrogenase catalyst [8]. In the measurement of SGPT, the reagent used contains tris buffer, L-alanine, lactate dehydrogenase, α -ketoglutarate, and NADH. SGPT will catalyze the amino group of α-ketoglutarate and L-alanine to form glutamate and pyruvate Pyruvate is reduced with the help of lactate dehydrogenase to form L-lactate while NADH is oxidized to form NAD [9]. Rat blood serum that has been obtained taken as much as 50 µl with a micropipette, mixed with 600 Ul of reagents, and then homogenized. Using a

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photometer, Samples combined with the respective reagents were measured for SGOT and SGPT levels.

Results and Discussion

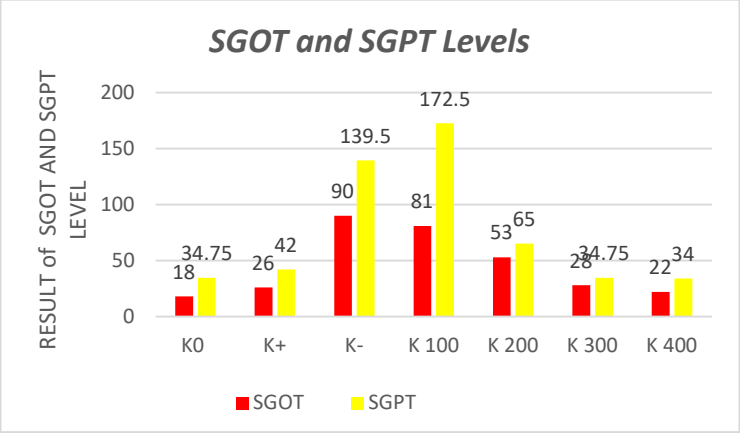
Measurement of SGOT and SGPT Levels in Male White Rats

The average results of SGOT and SGPT levels in rats given treatment have an influence compared to the control group of rats.

Table 1. Mean and SD Data of SGOT and SGPT Levels (U/L) of Male White Rats after **treatment**

Treatment	N	Mean and SD	
		SGOT	SGPT
K0	4	18.00 ± 0.95	34.75 ± 2.06
K+	4	26.00 ± 1.15	42.00 ± 1.41
K-	4	90.00 ± 2.21	139.50 ± 9.84
K 100	4	81.00 ± 9.89	172.50 ± 28.24
K 200	4	53.00 ± 1.91	65.00 ± 1.41
K 300	4	28.00 ± 1.41	34.75 ± 3.09
K 400	4	22.00 ± 1.91	34.00 ± 4.08

The table above shows that the decrease in SGOT and SGPT levels is based on the high dose of plant extracts given to each group of rats, each treatment group experienced a very significant decrease according to the high dose of extracts that had been given to the male rat group. This data is also shown in the graph below



Effect of Alloxan on SGOT and SGPT Levels

Alloxan is a diabetagonizing agent that selectively destroys insulin-producing cells, namely pancreatic β-cells. Compounds similar to glucose present in alloxan are the reason for its selective destruction. Because of its similarity to glucose, alloxan can enter the cytosol through the glucose transporter (GLUT2) in the plasma membrane of pancreatic β-cells. Alloxan induces a multiphase blood sugar response in experimental animals that will be followed by inversely proportional changes in plasma insulin concentration simultaneously with the final result in sequential changes in the structure of pancreatic β-cells that lead to cell death. The alloxan induction process's final phase is permanent diabetic hyperglycemia after the

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pancreatic β-cell degranulation process, which takes about 24-48 hours after alloxan administration in experimental animals [10].

In this study, we reported the K- rat group had higher SGOT and SGPT levels of 90.000 μ /L and 139 μ/L compared to the KO rat group, which had normal SGOT and SGPT levels of 18.00 μ/L and 34.75 μ/L. In alloxan-induced diabetic rats, SGOT and SGPT increased due to the damaging effects of alloxan-induced tissue where SGOT and SGPT seep and migrate into circulation [11]. Liver tissue in diabetic rats has significant increase in the production of lipid hydroperoxide (HP) oxidant radicals in line with decreased activity of antioxidant enzymes such as SOD, CAT, and gsh-px (12) Oxidative stress is also known to play an essential role in the regulatory mechanisms of cell conformity, proliferation, migration, and extracellular matrix signaling mechanisms, thereby altering the structure and permeability of cell membranes and intracellular organelles, such as mitochondria, rough endoplasmic reticulum, and affecting ion exchange, as well as protein synthesis, and oxidative processes.

Intracellular hyperglycemia can also activate adenosine dinucleotide phosphate oxidation (NADPH+), which plays a role in converting glucose to sorbitol. Accumulating sorbitol in the intracellular environment increases osmolarity and can lead to cell damage and death. Activation of the polyol pathway in diabetics will directly decrease the formation of antioxidant enzymes (GSH-Px), as the process depends on a reduced average level of NADPH, which may have been consumed in converting glucose to sorbitol. Hepatic stellate cells are activated during liver damage into proliferative and fibrogenic myofibroblast cells, decreasing NO (Nitric Oxide) levels and hepatic cell apoptosis. A cascade of signaling and transcriptional events in stellate cells underlies the fibrogenic response to liver damage, and regulation of NO release is a potential target for liver protection. NO plays a vital role in the antagonism of stellate cell activation, inhibition of platelet adhesion, and neutralization of oxygen free radicals, thereby preventing cell apoptosis. Endothelial nitric oxide synthase (eNOS) controls NO production, which is part of a negative feedback loop to block inflammation and damage to liver cells. TNF-α inhibition mediated by S-nitrosylation and caspase activity is NO's most widely characterized mechanism for apoptosis inhibition. It may be effective in cells that can efficiently limit inflammation and damage. Decreased eNOS expression in chronic liver diseases may reduce liver perfusion and accelerate fibrosis. Therefore, NO production mediated by hepatic eNOS can maintain normal arterial and portal venous blood flow in the liver! Deficiency of eNOS-derived NO aggravates liver damage, and overexpression of eNOS-derived NO protects against liver damage. In mice, eNOS activity is reduced in the liver after chronic ethanol exposure, which correlates with liver damage, especially activation of the Inflammatory factor NF-κB and expression of TNF-α. The activity and expression of eNOS are regulated by the phosphorylation state of phosphatidylinositol 3-kinase (PI3K) and extracellular regulated protein kinase (ERK) pathways. Overall, activation of eNOS via the PI3K/ERK-dependent signaling pathway is associated with reduced liver damage [13].

Effect of Extract Dosage on SGOT and SGPT Levels

Health is essential for human survival. Without a healthy body, humans will experience difficulties carrying out all their activities. Worry, stress, and fear can cause a person's health to decline [14]. Antioxidants are needed that can help protect the body from the influence of free radicals and reduce their negative impact [15]. Ginger has tropical insulin properties that can act as an antioxidant agent. This content can also be used as an antidiabetic. The content of ginger is phenol compounds containing zingeron, gingerol, and shogaol, which have antioxidant effects [16]. Alanine aminotransferase (ALT) or Serum Glutamic Pyruvic transaminase (SGPT) and Aspartate aminotransferase (AST) or Serum Glutamic Oxsaloacetic transaminase (SGOT), are enzymes whose presence and levels in the blood are used as markers

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of impaired liver function. These enzymes usually reside in liver cells. Damage to the liver will cause these liver enzymes to escape into the bloodstream so that their levels in the blood increase and indicate impaired liver function.(17)

The Shapiro-Wilk normality test analysis results state that all data are typically distributed. Furthermore, ANOVA analysis was carried out where for SGOT levels, the data obtained *p-values*> 0.05 and a significance value of 0.994>0.05, which indicates that the results are not significantly different. The next step is carried out the Duncan analysis test and obtained significant different results, where it can be concluded that there is an effect of different doses of a mixture of ginger, lemongrass and cinnamon bark extracts on SGOT and SGPT levels of male Wistar rats who are diabetic due to alloxan Induction. In the results of SGPT analysis using the *Shapiro-Wilk* normality test, the data obtained *p-values*> 0.05 and a significance value of 0.997> 0.05, indicating that the results are not significantly different. So, the next step is to do a Duncan analysis. It was found that the doses of 300mg/BW and 400mg/BW have a significance value <1.00, which means that the doses of 300mg/BW and 400mg/BW affect reducing SGOT and SGPT levels. Meanwhile, the doses of 100mg/BW and 200mg/BW have a significance value =1.00, which means that there is no significant effect of giving a mixture of ginger, lemongrass, and cinnamon bark extracts on the levels of SGOT and SGPT of male Wistar rats who are diabetic due to alloxan induction.

Table 1 shows that SGOT and SGPT levels in the K0 group have normal levels of 18.00 µ/L and 34.75 µ/L. This group of rats had regular activity treatment for 21 days, which was only given food and drink. The K-rat group is a group of rats induced by alloxan and offered no other treatment, which has high levels of SGOT and SGPT, namely 90 µ/L and 139.5 µ/L, where the results of this analysis are very far from the expected levels of SGOT and SGPT. This is because insulin-resistant Diabetes Mellitus patients have a risk of increasing SGOT-SGPT. After all, the liver's task becomes heavy due to one of its functions to produce glucose being inhibited; as mentioned earlier, in a state of insulin resistance, the liver's ability to produce glucose is impaired [18]. This is what can cause the liver to become heavy, thus affecting SGOT and SGPT levels in the K+ group of rats or in the group of rats given oral medication in the form of metformin, experienced an Increase in blood sugar levels and then after treatment, the results of the SGOT and SGPT analysis levels showed that it was close to the SGOT and SGPT levels of the KO group or normal levels of 26 µ/L and 42 µ/L (G For the group of rats given a mixture of plant extracts, it is apparent in the K100 group that the high SGOT and SGPT levels resemble the SGOT and SGPT levels of the K-rat group where it can be concluded that the dose given does not affect the decrease in SGOT and SGPT levels. In the K200 rat group, it can be seen that there is a reduction in SGOT and SGPT levels, namely 53 µ/L and 65 µ/L where it can be concluded that giving a dose of 200mg/KgBW extract can reduce the SGOT and SGPT levels of rats better than the dose of 100 Another significant decrease in SGOT and SGPT levels can be seen from the data of the K300 rat group of 28 µ/L and 34.75 µ/L and K400 where the results of the SGOT and SGPT analysis levels in the rat group of 22 µ/L and 34 µ/L are in the regular or stable range for normal SGOT and SGPT levels, namely SGOT= ≤ 37 µ/L and SGPT= ≤ 41 µ/L and close to the SGOT and SGPT levels of the KD rat group. So it can be said that the administration of a mixture of ginger, cinnamon bark, and lemongrass plant extracts that can reduce SGOT and SGPT levels to normal or stable is most effective at a dose of 300mg/Kg58 and a dose of 400mg/KgBW.

The main antidiabetic compounds contained in ginger, lemongrass, and cinnamon bark that have bioactivity as antidiabetics are flavonoids, tannins, saponins, sinamelhida, and alkaloids have bioactivity to counteract toxins that enter the body. The action mechanism makes the

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intestinal membrane more permeable, inhibiting glucose absorption [19]. These three plants contain the same chemical compounds, so the interaction between the content of the three sample extracts will not have a negative but positive effect on reducing SGOT and SGPT levels in male rats affected by diabetes

Conclusion

Based on the research that has been done, it can be concluded that

1. Give a mixture of ginger plant extracts (*Zingiber officinale*). lemongrass plants (*Cymbopogon citratus*), and cinnamon (*Cinnamomum burmanit*) influences reducing or stabilizing SGOT and SGPT levels in the body based on specific doses and time periods.
2. The dose of cinnamon extract that is effective for reducing or stabilizing SGOT and SGPT levels in the body is a dose of 300 mg/KgBW and a dose of 400 mg/kgBW with SGOT levels = ≤ 37,00µ/L dan SGPT = ≤ 41,00 µ/L. Where SGOT levels SGOT = 28,00 µ/L. 22,00U/L and SGPT= 34,75 µ/L, 34,00 µ/L.
3. A 200 mg/KgBW plant extract dose can reduce SGOT and SGPT levels to normal levels, but not yet stable. This group of rats had SGOT levels = 53,00 µ/L dan SGPT = 65,00 µ /L.

Acknowledgment

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Antibacterial and antioxidant activity of 5,6-dehydrokawaine compound from *Alpinia malaccensis* seeds

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Abstract. *Alpinia with its local name as lengkuas is a member of the Zingiberaceae family. Alpinia has more than 230 species and one of its species that has not been widely studied but has been used as a traditional medicine is Alpinia malaccensis. 5,6-dehydrokawain is of the main compound extracted from the seeds of A. malaccensis. The aims of this study were to examine the activity of the acetone extract of A. malaccencis seeds and the compound 5,6-dehydrokawain against Bacillus subtilis and Vibrio cholerae bacteria. The antibacterial activity test was carried out in vitro, which included determining the Minimum Inhibitory Concentration using the Microdilution method M07-A9 Clinical and Laboratory Standard Institute (ClSI). The antioxidant test was carried out by using the DPPH method. The acetone extract of A. malaccensis seeds showed strong activity against V. cholera and B. subtilis bacteria with MIC values of 37.5 µg/mL and MBC values of 75 µg/mL for v.cholera and >150 µg/mL respectively for B. subtilis. 5,6 dehydrokawain showed weak antibacterial activity against these two bacteria with a MIC value of 219.3 µg/mL and the MBC value was twice the MIC value. 5,6 dehydrokawain shows inactive antioxidant activity with an IC_{50} of 4322.4005 ppm.*

Keywords: *A. malaccencis*, 5,6-dehydrokawain, antibacterial, antioxidant

Introduction

A. mallacensis is a herbal tree and known by the local names as laja gowah, kamijara or galangal malacca. This type of plant is herbaceous, sturdy, about 1 to 4 meters high. The stem of *A.*

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mallacensis has many leaves, white flowers are arranged in its bunch. *A. mallacensis* originates from India on the island of Java, can be found especially in West, Central, and East Java. It grows at an altitude of 2-1,500 m above sea level and likes shady places. All parts of the body of the *A. mallacensis* smell good. The leaves and tubers contain essential oils that smell fragrant. This plant has benefits in traditional medicine. The pounded tubers are used to treat wounds. The fruit can be used for medicine and cooking spices. The fruit peel is used to wash clothes and perfume hair [1].

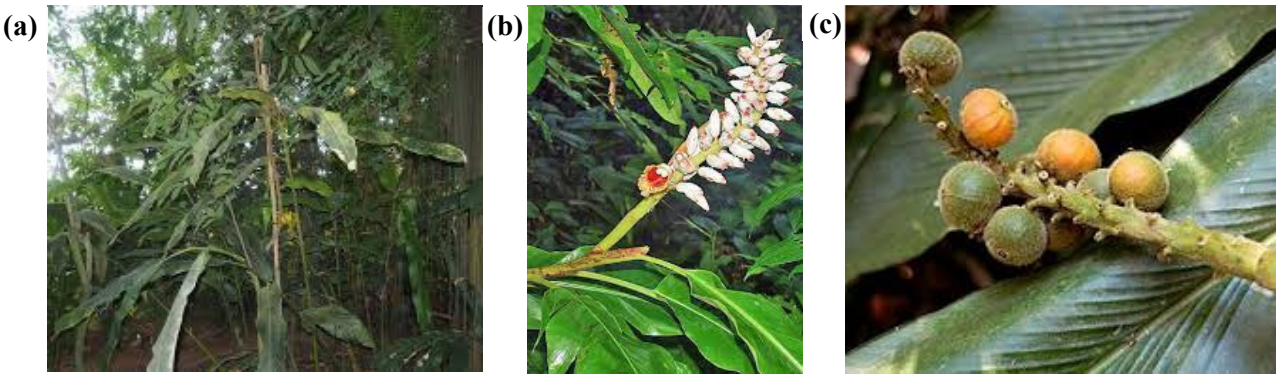

Figure 1. (a) Tree, (b) flowers, and (c) fruit of *A. mallacensis*

A. mallacensis has been used in traditional medicine. Phytochemical studies have been carried out on seeds *A. malaccensis* showed that this species produces several types of secondary metabolites with the main compound being 5,6-dehydrokawaine. [2]. Results of scientific studies of the chemical components of the genus *Alpine*, shows various biological properties, namely as antiinflammatory, anticholesterol, antioxidant, anti-HIV, anticancer, hepatoprotector, antiplatelet and antimicrobial. The results of research on methanol extract from leaves*A. malaccensis* showed good antioxidant activity, with IC_{50} 22.5 µg/ml against*1,1-diphenyl-2-picrylhydrazyl* (DPPH) and 26.23 µg/ml to *2,2-azino-bis(3-ethylbenzthiazoline-6-sulphonic aci*d) (ABTS). Ethanol extract from rhizomes *A. officinarum* exhibits antibacterial and antiinflammatory activity [4]. The biological activity of other species is from extracts *A.zerumbet* has activity as an antifungal, diuretic and anti-hypertensive , so this *Alpinia* genus has potential as a source of medicinal compounds. [5]

Methodology

Materials

5,6-dehydrokawaine was obtained from the results of previous research [2]. Gram-positive bacterial culture viz *Bacillus subtilis* and culture of gram-negative bacteria, namely Vibriocholera obtained from the Bandung POLTEKES microbiology laboratory. technical acetone, *Mueller-Hinton agar* (MHA) (Oxoid). *Mueller-Hinton Broth* (MHB) (Himedia), dimetilsulfoksida (DMSO) p.a (Sigma Aldrich), NaCl p.a (Sigma Aldrich), DPPH, methanol p.a (Sigma Aldrich).

Methods

Preparation of Inoculum Suspension

The inoculum is prepared based on the growth method, by dissolving 3-5 bacterial colonies in 4-5 mL of 0.9% NaCl. Next, the turbidity was adjusted to a turbidity of 0.5 Mc.Farland. The 5,6-dehydrokawaine test solution was made in a concentration of 438.6 ppm and *A. malaccencis* seed extract in a concentration of 600 ppm with DMSO solvent. The comparison used is

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Chloramphenicol.

Determination of MIC using Microdilution Method (CLSI-M07-A9)
Determination of MIC follows the procedure carried out by juwitaningsih [6]. Briefly, it is done as follows: insert MHB liquid media into column no. 1 (negative control) and MHB suspended bacteria into column no. 2 (positive control) and columns 3 to 12 are filled with MHB suspended bacteria and samples with various concentrations. The amount of solution in each well is 100 µL. *Microplate* then incubated at 37^{O}C for 24 hours. As a standard antibiotic, chloramphenicol is used. Determination of the MIC endpoint by comparing positive control holes and positive controls [7].

Determination of MBC
Determination Minimum Bactericidal Concentration (MBC) is carried out following the juwitaningsih and Igbinosa procedure [6,8]. The method is to take 10 µL from each hole*microplate* then grown on agar media and incubated for 24 hours at 37^{O}C.

Preparation of 0.004% DPPH solution
DPPH was made in a concentration of 40 ppm, by weighing 6 mg of DPPH powder, then diluting it with methanol p.a in a 150 mL volumetric flask.

Maximum wavelength screening
The 0.004% DPPH solution was vortexed and left for 30 minutes, then measured with a UV-vis spectrometer, to obtain the maximum wavelength and absorbance value.

Measurement of sample absorbance
About 2 mL of each test solution was pipetted, 2 mL of 0.004% DPPH was added, then vortexed and left at room temperature for 30 minutes, then the absorption at the optimum wavelength was measured. Each sample concentration was repeated twice [9]. Data analysis calculation of the percentage of antioxidant activity can use the formula:

$$\%\ \text{inhibition} = \frac{(\text{control absorbance} - \text{sample absorbance})}{\text{control absorbance}} \text{x } 100\%$$

then a graph is made between the concentration and the average % antioxidant activity to obtain the value y = bx + a. IC_{50} value (x) is calculated using the following formula = $\frac{50-a}{b}$

Result and discussion

Antibacterial activity

Antibiotics are natural or synthetic compounds that have the effect of suppressing or stopping biochemical processes in organisms, especially in the process of infection by microbes [10].

The way antibacterial compounds work is bacteriostatic or bactericidal. Bacteriostatic is determined by determining the MIC, which is intended to the lowest concentration of an anti-bacterial agent that inhibits bacterial growth. Bactericidal is determined through MBC measurements which are intended to determine the antibacterial agent that kills bacteria.

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In this study, the antibacterial properties of acetone extract from *A. malaccensis* seeds and the 5,6-dehydrokawaine compound were tested against two pathogenic bacteria, with the purpose of testing whether these compounds have potential as antibiotic compounds.

Table 1. MIC, MBC values of *A. malaccensis* seed extract and 5,6-dehydrokawaine

Sample	*v.cholera* (gram-negative)		*B. subtilis* (gram-positive)	
	MIC (µg/mL)	MBC (µg/mL)	MIC (µg/mL)	MBC (µg/mL)
A. malaccensis seed extract	37.5	75	37.5	> 150
5,6-dehidrokawain	219.3	438.6	219.3	> 438.6
Chloramphenicol	12.5	12.5	3.1	3.1

Table 1 shows data on antibacterial activity test results. Seed acetone extract of *A. malaccencis* showed antibacterial activity against both bacteria with an MIC of 37.5 mg/mL and an MBC value of two times the MIC for *v.cholera* and for bacteria *B. subtilis* requires a concentration of >150. This is in line with previous studies, namely extracts from genus species *Alpinia* like *A. galangal* (Linn) Wild [11, 12], *A. calcarata* Rosc, *A. allunghas* shows antibacterial activity. An extract is categorized as active if the MIC value is less than 100 µg/mL, moderate if the MIC value ranges between 100 < MIC < 625 µg/mL, and inactive if the MIC value is > 625 µg/m [13]. Based on these criteria, acetone extract *A. malaccensis* actively inhibits bacterial growth. This is in line with the use of *Alpinia* rhizomes for the treatment of stomach aches by people in China and Thailand [14].

Meanwhile, the antibacterial activity test of the isolated compound showed that the phenylpropanoid compound, namely 5,6 dehydrokawain, showed antibacterial activity with an MIC value of 219.3 µg/mL, thus the compound 5,6-dehydrokawain was not active against bacteria *V. cholera* and *B. subtilis*. When compared between the activities of the extracts, they show active activity against bacteria *V.cholera* and *B. subtilis* while the compound 5,6-dehydrokawain shows inactive activity, this shows that the activity of the extract is contributed by secondary metabolites contained in the extract, which work synergistically. The following are several classes of compounds reported to be contained in the species *A. malaccensis* which includes 5,6-dehydrokawain (1) which is a phenyl propanoid derivative, compound (2) – (5) is a diterpene with a labdan framework, namely 3-((E)-2-((4aS,8aS)-5,5,8a-trimethyl-2 methylenedecahydronaphthalene-1-nil)furan, (4aS,8aS)-4-((E)-2(furan-3-nyl)vinyl-4a,8,8-trimethyl-3- methylenedecahydronaphthalene-2-ol compound (3), (E)-2-(2-((4aS,8aS)-5, 5,8a-trimethyl-2- methylenedecahydronaphthalene-1-nyl)ethylidene)succinaldehyde. Compounds (4) and (5) are 3-((E)-2-((4aS,8aS)-3-hydroxy-5,5,8a-trimethyl -2- methylenedecahydronaphthalene-1-nyl)vinyl)furan-2(5H)-non, compound (6) namely (E)-1-(2,4-dihydroxy-6-methoxyphenyl)-3-phenylpro-2-en-1-non is a flavonoid with a chalcone skeleton and compound (7), namely 5,7-dihydroxy-2-phenylchroma-4 -non and 7-hydroxy-5-methoxy-2-phenylchroma-4-non, compounds (8) is a flavonoid with a flavanone skeleton. Structure of the compounds can be seen in figure 2.

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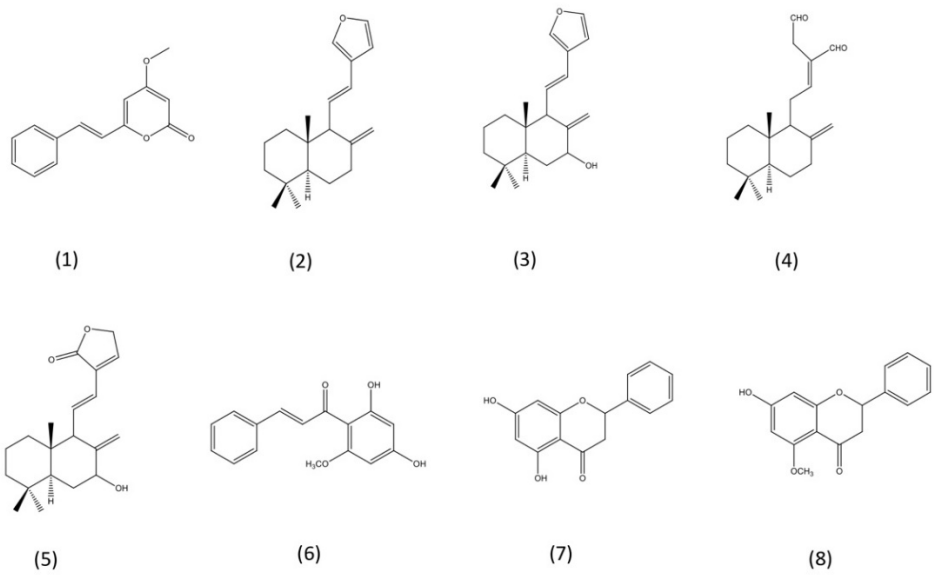

Figure 2. Several classes of compounds are reported to be contained in the species A. malaccensis

Although the compound 5,6-dehydrokawaine is not active against *V.cholera* and *B. subtilis* bacteria, but the compound 5,6 dehydrokawaine shows moderate activity against *L. monocytogenes* strains and the fraction containing 5,6 dehydrokawaine shows strong activity against *L. monocytogenes* strains, with inhibition zones 9 mm and 13 mm [13,15]. The results of this study also show the activity of the fraction containing several secondary metabolite compounds, the activity is better than the activity of the pure compound. The results of Minth et.al's research confirm that the antibacterial activity *A. malaccensis* contributed by the synergistic action of the secondary metabolites it contains.

Antioxidant Activity

Antioxidants are compounds that have a molecular structure that can give electrons to free radical molecules without their function being disrupted at all and can break the chain reaction of free radicals [16]. Antioxidant activity parameters were measured by IC_{50} values. IC_{50} is the concentration of the test solution that is able to reduce 50% of DPPH absorbance. Observations on the capture of DPPH radicals were observed in the decrease in absorbance. This can occur due to radical reduction by antioxidants or reacting with other radical compounds. The following table 2 is the absorbance data 5,6-dehidrokawain.

Table 2. Antioxidant activity test data of 5,6-dehydrokawain

No.	Concentration (ppm)	Absorbance		% Inhibition	
		1st repetition	2nd repetition	1st repetition	2nd repetition
1.	0	0.8688	0.8688	0.0000	0.0000
2.	1200	0.7336	0.7206	15.5617	17.0580
3.	2400	0.5997	0.5993	30.9738	31.0198
4.	3600	0.4826	0.4941	44.4521	43.1285
5.	4800	0.3838	0.3921	55.8241	54.8688
6.	6000	0.2863	0.2959	67.0465	65.9415

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Based on the % Inhibition data, a regression line equation was created as shown in Figures 3 and 4.

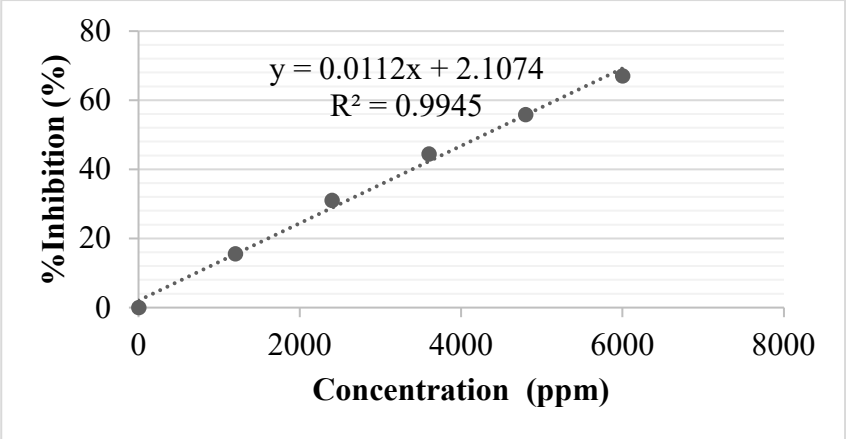

Figure 3. Concentration vs % Inhibition diagram of 5,6-dehydrokawaine from 1st repetition

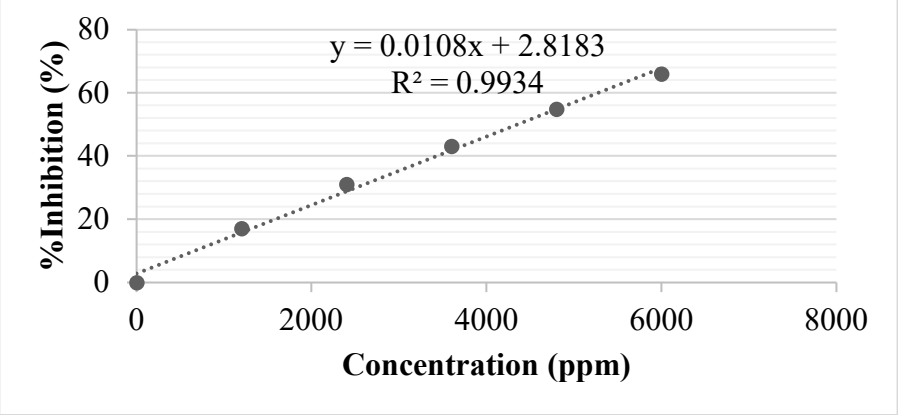

Figure 4. Concentration vs % Inhibition diagram of 5,6-dehydrokawaine from 2nd repetition

From the two regression equations, the IC_{50} value is obtained as stated in table 3.

Table 3. Antioxidant activity data (DPPH)

No.	Sample ID	IC_{50} (ppm)		
		1st repetition	2nd repetition	Average
1.	Isolat 5,6-dehidro kawain	4276.1250	4368.6759	4322.4005

The sample is declared as a very strong antioxidant if the IC_{50} value <50 ppm, strong if IC_{50} value 50-100 ppm, moderate if IC_{50} value 100-150 ppm, weak if IC_{50} value151-200 ppm, and is declared inactive if it has an IC_{50} value >200 ppm [17], From the criteria, the 5,6-dehydrokawaine compound does not act as an antioxidant. The results obtained are consistent with previous research findings flavanones show superior activity compared to kavalactones [15] and may be a reaction

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time of 30 minutes is not enough to cause a reaction, which compromises the antioxidant capacity 5,6-dehidrokawain ignored.

Conclusion

The activity of acetone extract of *A.malaccencis* seeds shows strong antibacterial activity against *B. subtilis* and *V. cholera* bacteria. Meanwhile, the compound 5,6 dehydrokawain shows weak activity, both as an antioxidant and as an antibacterial against the *B. subtilis* and *V. cholera* bacteria.

Acknowledgments

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Student Support Program in Formulating a Research Framework

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Abstract. *The author found that the research framework formulated by students in the master's program and doctoral program in the Unesa Postgraduate Science Education Study Program did not meet expectations. Ontologically, the percentage of research framework formulations that contain all research variables represented the construct of relationships between variables holistically is 6% for theses and 18% for dissertations. Epistemologically, a large number of students did not write down the certainty of the relationship between variables in order to present the state-of-the-art; there was no empirical evidence that explained the relationship between variables has been proven statistically. Due to weaknesses in the ontology and epistemology dimensions, axiologically was discovered that there was no clear functional relationship between the formulation of the research thinking framework and the research operational framework, discussion, and conception of research results. The author observed the same condition that also occurred in undergraduate chemistry education students' theses. Through deductive reasoning, the author formulates a thinking framework for program design to support students in formulating a correct research thinking framework. Three sub-programs have been designed, namely: (a) Student support program in formulating a research framework, (b) Writing a Reference Book for Formulating a Thinking Framework, and (c) Development of supporting tools for implementing the first sub-program.*

Keywords: researched framework, supported program, ontology, epistemology, axiology

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Introduction

Formulating a research framework is one of the stages that researchers must carry out in solving problems. The problem formulation contains relationships between variables, therefore the correct research framework formulation contains all research variables and represents the construct of relationships between variables holistically (ontology dimension). The research thinking framework was developed through deductive thinking (epistemology dimension) and functioning to guide further research stages (axiology dimension)[1].

An evaluation of 70 and 64 research framework formulations written by students of the master's program and doctoral program of the Unesa Science Education Study Program for the period 2018-2022 has been carried out. Table 1 presents the results of evaluating ontology dimensions of 10 theses which represent the results of analyzing the quality of research thinking frameworks developed by students of the Science Education master's program.

Table 1. Evaluation Results of the Formulation of a Research Thinking Framework for 10 Theses from the Ontology Dimension

No.	Indicator	Thesis Number									
		1	2	3	4	5	6	7	8	9	10
1.	The research thinking framework contains research variables	▨			▨	▨	▨	▨		▨	▨
2.	The variables stated in the problem formulation (research questions) must be contained in the research framework formulation.	▨			▨	▨	▨			▨	
3.	The research framework represents the construct of relationships between variables holistically	▨			▨		▨				
4.	The research framework consists of a series of literature quotations only.		▨	▨		▨		▨	▨	▨	▨
5.	Apart from those mentioned above		▨	▨		▨		▨	▨	▨	

Notes: ▨ fulfills the statement in column 2

When we pay attention to the evaluation indicators for the formulation of the research thinking framework ontologically (indicators 1 to indicator 5), then indicators number 1 and number 2 represent the incorrect formulation of the research thinking framework, indicator number 3 represents the correct formulation of the research thinking framework, and indicator number 4 and number 5 represents the incorrect research framework formulation. This indicator also applies to the evaluation of the research framework formulation in the dissertation, ontologically.

The presentation of the data in Table 1 and Table 2 provides an initial picture that the formulation of a research framework from the ontology dimension found only 30% of theses and 20% of dissertations whose research framework formulation represents the construct of relationships between research variables holistically[2]. This initial fact triggered the research team to evaluate the formulation of the research framework for theses and dissertation research in a larger number.

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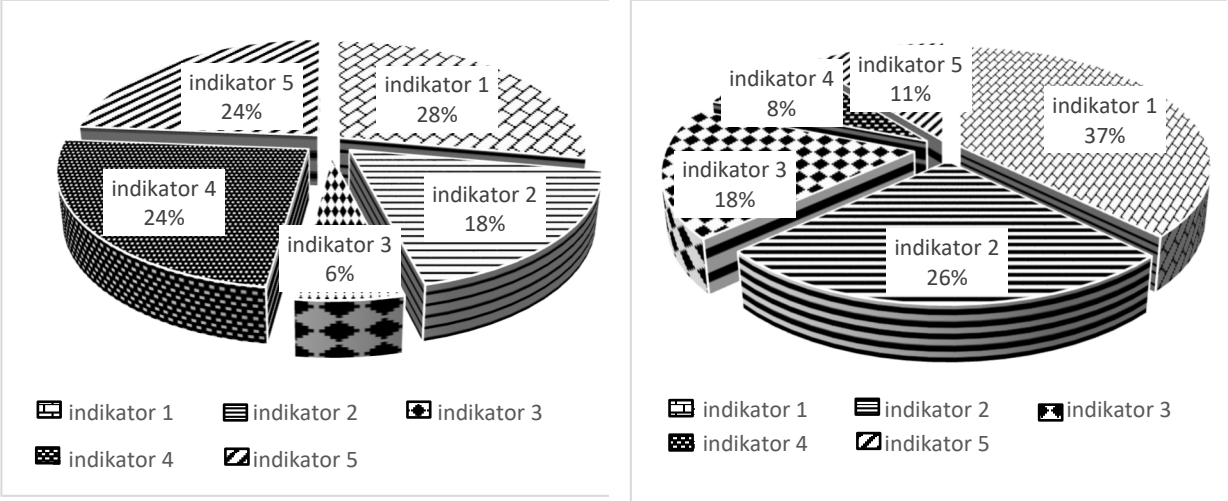
Table 2. Evaluation Results of the Formulation of the Research Thinking Framework for 10 Dissertations from the Ontology Dimension

No.	Indicator	Dissertation Number									
		1	2	3	4	5	6	7	8	9	10
1.	The research thinking framework contains research variables	▨	▨	▨		▨	▨	▨	▨	▨	
2.	The variables stated in the problem formulation (research questions) must be contained in the research framework formulation.	▨	▨	▨		▨	▨		▨	▨	
3.	The research framework represents the construct of relationships between variables holistically		▨				▨				
4.	The research framework consists of a series of literature quotations only.	▨		▨	▨	▨			▨	▨	
5.	Apart from those mentioned above								▨		

Notes: ▨ fulfills the statement in column 2

The results of the evaluation of the formulation of the research framework for 70 theses and 64 dissertations of Science Education Study Program students from 2018-2022, both in the dimensions of ontology, epistemology and axiology, found the following facts. The results of the evaluation of the ontological research framework formulation for 70 theses and 64 dissertations are presented in Diagram 1.



(a) (b)

Figure 1 (a) Proportion of Theses whose Research Framework Formulation is According to Sub Indicators Ontology Dimensions, (b) Proportion of Dissertations whose Research Framework Formulation is According to Sub Indicators Ontology Dimensions

Based on the data in Diagram 1, it is found that the percentage of thesis research thinking framework formulations that are categorized as correct, not correct and incorrect are 6, 46 and 48% respectively, while for dissertations it is 18, 63 and 19% respectively.

Epistemologically, a large number of students did not write down the certainty of the relationship between variables in order to present the state-of-the-art; There is no empirical

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evidence that explains that the relationship between variables has been proven statistically. Due to weaknesses in the ontology dimension and epistemology dimension, axiologically was found that there was no clear functional relationship between the formulation of the research thinking framework as a guide for the next research steps [2]. Based on the experience of testing thesis proposals, the author found the same phenomenon in the formulation of research thinking frameworks for undergraduate chemistry education students.

To overcome the gap above, the author wants to develop a program to support students in formulating a research thinking framework. The ability to formulate a research thinking framework is an important competency in carrying out research or the problem solving process. This article presents a formulation of ideas or initial stages of development which will immediately proceed to the next stage; develop, implementation, and evaluation.

Method

Program formulation begins by analyzing the position of the research thinking framework in the scientific method stages as presented in Diagram 2[1].

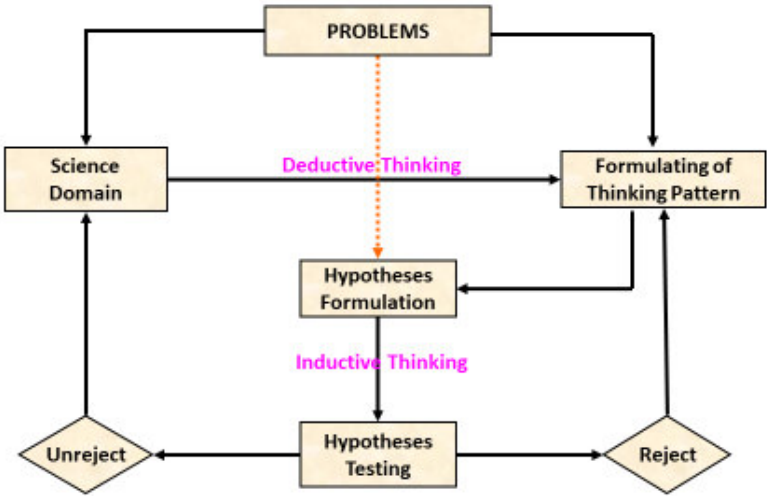

Figure 2. Scientific Method Diagram

The program formulated by the author at this time is the starting point for further development stages until it is proven feasible to implement. To identify these solution ideas, the author tries to follow the stages of thinking starts from the analysis to the implementation stage as in the ADDIE (Analysis, Design, Develop, Implementation, and Evaluation) design [3]. Related to the stages of the scientific method (Diagram 2), this article contains the results of the researcher's thinking from the analysis stage to the design stage which is equivalent to the formulation of the thinking framework in the scientific method.

The author carried out the formulation of a program to support student competence in formulating a research thinking framework by practicing deductive thinking. Analysis of data in the form of propositions related to the research framework was carried out using logical analysis.

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Program Formula

The propositions that were successfully collected by researchers regarding the research thinking framework are as follows. Ontologically, the research framework is defined as the holistic description of the variables to be studied and the relationships between these variables[4,5]. A research thinking framework is a conceptual model that describes the flow of research thinking or problem solving ideas[6]. A good research thinking framework can explain variables, show the relationship between variables along with the theory that designed them and show the form of relationship between variables [7]. The research thinking framework is a line of thinking which apart from being based on previous theories (textbooks), it is also based on empirical experience, including empirical experience experienced by other researchers (scientific articles). A research thinking framework is a logical construction of thinking with arguments that are consistent with previous knowledge that has been successfully compiled. Someone examines the problem in a theoretical framework through a research thinking framework [8].

Paying attention to the position of the research thinking framework in the scientific method stages (Diagram 2) as the main paradigm in research and basing on the propositions in the paragraph above, the results of the analysis can be given: (1) the research thinking framework was formulated in order to answer the research problem that has been formulated (problem formulation), (2) the research thinking framework is developed using deductive reasoning (deductive thinking), using propositions sourced from both textbooks and scientific articles, (3) providing a basis for proposing hypotheses, and (4) providing a basis for the operational framework of research or problem solving (research methods).

Based on the results of this analysis, student can improve their competency in formulating research thinking frameworks, it is necessary to develop innovative programs that provide learning experiences such as: (1) exploring hopeful propositions (das Sollen) and factual propositions (das Sein), (2) conducting gap analysis to identify problems, (3) carrying out exploration and elaboration to identify the main factors causing problems, (4) formulating (generating) research problems (research questions), (5) considering the conceptual and operational definitions of variables that have been written, (6) the practicing deductive thinking and argumentation to formulate a framework of thinking in order to fight for proposed problem-solving ideas, and (7) implementing the framework of thought into the research operational framework.

The learning experience of exploring, generating, fighting for, and implementing ideas can encourage the formation of innovation competencies[9,10]. The author wants to formulate alternative solutions for improving student competency in formulating a research thinking framework, which has a long-term target or goal of increasing their innovation competency. Because in the 21st century, in the global era, in the era of industrial revolution 4.0, the educational graduates who are employed are those who have innovation competencies[11]. Innovation competency can be influenced, taught, and changed in nature[9]. Meanwhile, there is criticism that higher education is too late in teaching its students to have innovation competencies. Universities still tend to emphasize standards, accountabilities and risk managements, lacking the courage to take risks[12,13]. The Ministry of Education and Culture responded to this criticism explicitly that the implementation of the learning process in higher education is carried out by creating a learning atmosphere that is fun, inclusive, collaborative, creative and effective ([14]Article 14 paragraph 1a). Innovation competence contains creative competence [15].

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First Sub Program: Student Support Program in Formulating a Research Framework

This solution idea can be expressed as an innovation program. A program is a set of educational activities that are arranged in such a way that they can be carried out by students within a specified time (Big Indonesian Dictionary). This program develops thinking and innovation skills that do not follow the traditional lecture-based design. This program encourages students to be involved in the process and be at the center of the process, including the project completion process [16]. Programs that do not place too much emphasis on standards, accountabilities and risk managements [12,13].

The first solution idea is implementing a program that encourages students to develop a framework of thinking outside the curriculum structure; in the form of self-service. Independent services that can be provided to undergraduate students, master's programs and doctoral programs in preparing theses, theses or dissertations. A thesis is a form of final assignment given to undergraduate students to ensure the achievement of graduate competencies ([14]Article 18 paragraph 9a). In the same regulation, it is stated that a thesis is a form of final assignment that must be given to students in master's programs ([14]Article 19 paragraph 2) and a dissertation is a mandatory final assignment for doctoral program students ([14]Article 20 paragraph 3). Meanwhile, in Article 16 paragraph 2c, independent activities are a form of learning. The solutions offered are part of efforts to provide a platform to facilitate students' independent activities in research or problem solving. The program implementation stages adapt the learning stages of the Project-Based Learning (PjBL) model.

PjBL is one of the learning models recommended by Permendikbudristek No. 53 of 2023 (Article 18 paragraph 9a). One of the trends in Education 4.0 is PjBL [17,18]. A number of researchers have proven the superiority of using PjBL in learning[19–22].

The first step of the PjBL model is choosing a focus for the project[23,24]. Mistakes in formulating a research thinking framework are a real problem in student life. This problem must be solved systematically and massively. This problem can be used as a focus in the differentiation of the PjBL model. The program developed named "Student support program in formulating a research framework (SSPinFRF)." This program can be managed offline or online[25].

Ten stages have been designed in the implementation of SSPinFRF. The ten stages along with the theoretical and empirical foundations that underlie the determination of each stage are as follows.

Stage 1: Orientation, contains activities to equalize perceptions about SSPinFRF and the competencies that must be achieved through this program and documents (portfolios) that must be created. Activities are carried out face to face with facilitator lecturers and information literacy assignments. The deductive basis for determining stage 1 is: (1) Fleming (2000) reminds students need to provide students with an understanding of PjBL so that they do not experience difficulties in implementing it and (2) In managing PjBL, students are activated to seek information themselves[26].

Stage 2: Determining the project focus, the facilitator lecturers and students agree on the project focus, namely the development of a framework of thinking that will be written in the student's thesis or dissertation proposal. The deductive basis for determining stage 2 is: (1) Learning in innovation programs can be carried out by involving students in completing problem solving projects[27], (2) Students are at the formal operational cognitive development stage. At this stage of thinking, individuals are able to think abstractly; thinking about ideas and considering various alternative problem solutions[28], not only (3) Interaction between lecturers and students but also students with students is considered in developing the model[29]. The facilitator lecturer

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coordinates deliberations to ensure the problem (research question) is resolved which will serve as an orientation for the activity of formulating a research framework. The resolved problems are certainly different from one student to another.

Stage 3: Defining the innovative project and establishing a timeline. The lecturer facilitates discussions and clarifications to: (1) determine the focus of the thinking framework development project for each student who is different from one another, (2) agree on a timeline for completing the portfolio. Portfolio in the form of a document containing the results of exploration activities, generation, practice of deductive thinking and argumentation to formulate a framework for thinking in order to fight for problem solving ideas, and plans to implement the framework of thought into a research operational framework. The deductive basis for determining stage 3 is that: (1) Skills in planning projects have been empirically proven to be related to innovation competence[12], (2) Innovation is any idea, method/procedure, or new product that can be proposed[9,30], (3) Lecturers and students can contribute to each other's knowledge, experience and skills[31], (4) PjBL is designed to practice time management[17,18], and (5) students are free to choose sources of information when exploring and do not have to be uniform in assignments[17,18]

Stage 4: Portfolio Development-1, formulation of problem background. The student learning experiences that are conditioned at this stage are: (1) exploring hopeful propositions (das Sollen) and factual propositions (das Sein) about the topic being researched and (2) carrying out gap analysis to identify problems. The deductive basis for determining stage 4 is that: (1) Creative thinking occurs when someone carries out exploration and elaboration to develop ideas[32], (2) Idea creation involves 4 (four) stages, namely exploration, generation, struggle, and implementation[9,15], (3) To be able to develop students' innovation competencies, a learning environment is needed that will encourage successful learning in developing innovation competencies[12], and (4) The need for an environment that creates opportunities for students to interact with learning resources to support their development[33].

Stage 5: Portfolio-1 assessment and collaborative feedback. The student learning experiences conditioned on stage 5 are: (1) providing opportunities to clarify the results of the portfolio-1 assessment and feedback notes provided by the facilitator lecturer as an implementation of assessment as learning and (2) collaborative practice in providing and/or obtaining input from colleagues. The deductive basis for determining stage 5 is that: (1) Student portfolios[34] can be used as material for portfolio assessments of student performance[35], (2) Delivery of feedback on results follows the principle of assessment as learning[22,36], (3) Communication skills possessed by an innovator[30,37], (4) Open-mindedness is one of the characteristics an innovator[30,38–40], (4) One's open mind is needed when someone has to change the results of thoughts that are not correct and changes in thinking can occur in a person goes through a process of disequilibration and equilibration[41], and (5) New information obtained from class discussions through a process of assimilation and accommodation can help a person correct mistakes to reach a higher level of cognition[42].

Stage 6: Portfolio Development-2, formulation of research questions. The student learning experiences that are conditioned at this stage are: (1) carrying out exploration and elaboration to identify the main factors causing the problem, (2) formulating (generating) a research problem (research question), and (3) reflecting on the conceptual and operational definitions of the variables involved. has been written in the problem formulation. The deductive basis for determining stage 6 is that a way to activate students' cognitive working memory so that the competencies they have acquired can be stored in long-term memory is maintenance rehearsals (repeating new information in the mind)[41]. Based on Woolfolk's theoretical foundation, after the portfolio-1 assessment stage and providing feedback, students are involved again in developing portfolio-2.

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Stage 7: Portfolio-2 assessment and collaborative feedback. The student learning experience conditioned on stage 7 and the supporting deductive basis are the same as those that apply to stage 5. Continuous evaluation must be carried out from the start of the process to ensure the productivity of student performance over time[16].

Stage 8: Portfolio Development-3, formulating a thinking framework for problem solving. The student learning experiences that are conditioned at this stage are: (1) practicing deductive thinking and argumentation to formulate a framework for thinking in order to fight for problem-solving ideas and (2) implementing the framework of thinking into an operational research framework. The deductive basis for determining stage 8 is the same as that applied to determining stage 6.

Stage 9: Portfolio-3 assessment and providing collaborative feedback. The student learning experience that is conditioned on stage 9 and the supporting deductive basis is the same as that which applies to stage 5 or stage 7.

Stage 10: Reflection of project results. Students are given assignments with looking at their portfolio collection (three documents portfolio-1, portfolio-2, and portfolio-3) and feedback notes provided by the facilitator lecturer, as well as notes obtained from the communication process through collaborative discussions. The student learning experience conditioned on stage 10 is independence in thinking and working, such as: (1) writing the results of reflections on the three portfolios that have been developed and (2) presenting a follow-up formula for improving the portfolio, including improving the research thinking framework which is formulated as the final product of the project undertaken. The deductive basis for determining stage 10 is that innovative students have a positive attitude and orientation towards self-improvement[30].

The first sub-program, which consists of 10 stages, is still purely hypothetical and needs to be tested for feasibility, developed supporting tools and assessment instruments.

Second Sub Program: Writing a Reference Book, Formulating a Thinking Framework

To support the first sub-program in efforts to improve student competency in formulating a research thinking framework is the provision of a Reference Book for Formulating a Thinking Framework (RBFTF). A reference book is a scientific writing in the form of a book whose discussion substance focuses on one area of study [43]. Formulating a research thinking framework is one of the important areas of study in the practice of scientific thinking[1]. Theses, theses and dissertations are three of the products of scientific thinking[14]. A discussion of the correct formulation of a research thinking framework can be determined as the focus of the study area of a reference book. The correct formulation of a research thinking framework can be reviewed based on three scientific questions, namely ontology, epistemology and axiology[44]. Currently the author is developing BRPKB. As a result of searching the literature, researchers did not find a special book like this. Instructions regarding the formulation of a research framework are not discussed in depth in books on research methodology or philosophy of science.

Reference books are scientific writings in book form whose discussion substance focuses on one field of science[43]. Reference books are flexible and do not refer to existing curricula; is a type of non-text book[45,46]. Criteria for reference books include appropriateness of content/material, presentation, language and graphics[46]. To make understanding easier , reference books use simple language accompanied by illustrations and text examples based on the objects presented and the material is presented coherently[47].

The strategy for writing reference books is carried out by designing or converting existing research results/author's ideas, by using changes in the anatomy of research results into the anatomy of reference books[48]. The order of material and structure of textbooks is arranged based on the logic of the field of science (content oriented) [43]. Reference books contain the latest facts,

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concepts or theories, there are no fatal conceptual errors, they are accurate in describing the discussion. The contents of reference books must be comprehensive and consistent with the characteristics of the field of study; is on the path of the field of science[47].

The design of the chapter contents of the RBFTF that is being written is: CHAPTER I FRAMEWORK OF THINKING, Dimensions of Hope (das Sollen), CHAPTER II FRAMEWORK OF THINKING, Dimensions of Reality (das Sein), CHAPTER III SYLOGISM IN FORMULATION OF FRAMEWORKS OF THINKING, CHAPTER IV LOGICAL FALLACY AND FRAMEWORK OF THINKING, and CHAPTER V FORMULATION OF A FRAMEWORK OF THINKING AS A CORE PROJECT IN PjBL (Project-Based Learning) PRACTICE IN STUDENT RESEARCH.

The contents of Chapters I, II and IV in anatomy changes resulting from research carried out by the author from 2020 to 2023 in the anatomy reference book. The results of research that has been carried out are as follows. Students' argumentation skills in assessing content in viral videos[49]. Analysis of chemistry students' reasoning errors in arguing[50]. Development of chemistry lecture tools to reduce logical fallacies in arguments[51]. The author is a member of the research chaired by Sukarmin. Evaluation of the thinking framework in the thesis and dissertation of the Unesa Postgraduate Science Education Study Program[2]. Development of a reference book for formulating a framework for thinking[52]. The substance in these three chapters is enriched from the results of research conducted by other researchers.

To fulfill the RBFTF's comprehensiveness and consistency with the characteristics of the field of study, namely the formulation of a research thinking framework, the contents of the RBFTF chapters, apart from being sourced from research results, also contain the latest concepts, principles or theories need to describe the discussion regarding the formulation of a research thinking framework.

The principles of syllogism as a way of deductive thinking in preparing elementary conclusions which form the basis for formulating a framework of thinking are studied in the RBFTF (Chapter III). Ideas for developing learning models that position the formulation of a thinking framework as a core project in PjBL (Project-Based Learning) practice need to be displayed in the RBFTF (Chapter V).

Third **Sub Program:** ***Development of Supporting Equipment for the First Sub Program***

This third sub program is an inseparable part of the first sub program. When this third solution idea becomes an inseparable part of the first sub-program, the program support tools developed are what is needed in the implementation of the SSPinFRF stage. The author has identified a number of program support tools as presented in Table 3.

Innovations in learning practices cannot become mainstream without changing previous practices, including in assessment. The assessment practiced in this third sub-program is portfolio assessment. Portfolios are all objects in the form of physical evidence as something that shows student performance results[35]. It is time for educators (lecturers) to leave closed-book exams and replace them with authentic assessment strategies[53]. Portfolio assessment is a form of authentic assessment[34].

Portfolio assessment does not just measure learning success, but rather assesses as learning[22,36,54]. Each portfolio is ideally assessed by two assessors and the two scores are averaged to produce a level of innovation competency achievement that represents appreciation for student performance. Assessing portfolios using two assessors increases the validity of the assessment, so that students obtain fairness for the portfolios created. If assessor scores differ by 9 points or more,

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the assessment coordinator reviews the portfolio to reconcile any discrepancies. To increase inter-rater reliability, assessment exercises need to be carried out before carrying out the actual assessment[34]. The assessment and feedback given by the facilitator lecturer on student portfolios can be used as material for students to carry out introspection or self-evaluation from time to time[35].

Table 3. Supporting Tools for the Research Thinking Framework Development Program

Stages	Program Support Tools
1	• Handout containing program objectives and program implementation scenarios (SSPinFRF syntax). • Student Activity Sheet to activate students' habits of exploring and elaborating information.
2	Handout containing: • Submitting information about the project focus, namely developing a research thinking framework or problem solving and • Explanation of the position of the research thinking framework in the scientific method.
3	Handout containing: • Contract statement of activities that students must carry out according to the program scenario and work contract of the lecturer team in facilitating, monitoring and evaluating student work results (portfolio). • List of student activities in developing portfolios and determining a time line for each activity such as collecting portfolios, collaborative assessment to provide feedback on each portfolio. Portfolio assessors apply assessment as learning.
4	Form containing signs for checking portfolio-1. This format was developed to guide students in reviewing the written problem background formulation.
5	Portfolio-1 assessment instrument accompanied by feedback notes from the facilitator lecturer and the thesis supervisor.
6	Form containing signs for checking portfolio-2. This format was developed to guide students in reviewing the formulation of (1) research questions and (2) conceptual and operational definitions of research variables that have been written. At the beginning of this format, a brief explanation of the Operational Definition of Variables (ODV) is given.
7	Portfolio-2 assessment instrument accompanied by feedback notes from the facilitator lecturer and the thesis supervisor.
8	Form containing signs for checking portfolio-3. This format was developed to guide students in reviewing the thinking framework that has been formulated.
9	Portfolio-3 assessment instrument accompanied by feedback notes from the facilitator lecturer and the thesis supervisor.
10	Signs or guidelines for: • Reviewing the substance of the three portfolios which have been revised according to feedback provided by the facilitator lecturer and colleagues. • Find possible weak points in the framework of thinking that has been formulated and write follow-up actions for improvement.

Conclusion

1. A gap detection of the research framework formulation developed by students in the master's program and doctoral program in the Science Education Study Program. This gap is indicated to also occur in undergraduate students' theses. The university needs to find a solution. A solution that does not disturb the curriculum structure that has been created rigidly.
2. Through analyzing theoretical and empirical propositions, the author carried out deductive thinking and succeeded in formulating three solution ideas for improving student competence

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in formulating a research thinking framework as an important competency in carrying out research or the problem solving process. The three sub-programs are: (a) Student support program in formulating a research framework, (b) Writing a Reference Book for Formulating a Thinking Framework, and (c) Development of supporting tools for implementing the first sub program.

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Improving student's critical thinking abilities through developing teaching materials using the PBL STEM model based on chemical literacy

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Abstract. *The ability to think creatively is one of the high-level abilities that students must have after completing their studies at university. This research aims to develop general chemistry teaching materials on electrochemistry using the PBL STEM model based on chemical literacy in an effort to improve students' critical thinking skills. The development model refers to the ADDIE development model, with research subjects of 30 students. This research produces an educational product in the form*

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of General Chemistry teaching materials (books) with a PBL STEM model based on Chemical Literacy on Electrochemical material and has been declared valid (feasible) based on teaching material suitability indicators from the National Education Standards Board (BSNP) with modifications according to the level of teaching materials. university. The implementation of the resulting teaching materials was also proven to be effective in improving students' critical thinking skills with an average increase (difference in post-pretest scores) of 28.933±6.654 as well as statistical hypothesis testing results with a probability value (p)= 0.000 < 0.05. Thus, it is concluded that the development and application of teaching materials using the PBL STEM model based on chemical literacy in electrochemistry learning can improve students' critical thinking abilities.

Keywords : chemistry education, critical thinking, chemical literacy, electrochemistry

Introduction

The world has now entered the 21st century, also known as the digital era, where technology has become the most basic thing and has brought the current generation into the world of digital literacy which has become integrated with the current condition of society [1]. The development of science and technology, especially in the fields of communication and information in the 21st century, has led to intense competition in the current era of globalization. Therefore, students must be able to overcome global challenges, such as critical thinking skills, the ability to communicate effectively, innovate and solve problems through negotiation and collaboration [2]. This has resulted in rapid changes in living arrangements and global changes in life. If students are not equipped with critical thinking skills, it is likely that students will not have the ability to retrieve, process and use the information they have in facing the challenges of everyday life [3].

Chemical material and critical thinking skills are two things that cannot be separated, because chemical material is understood through critical thinking and vice versa, critical thinking can be trained through studying chemistry. Critical thinking skills or abilities are very important for students because by having critical thinking skills students are able to be rational and choose the best alternative options for themselves. An educator, including lecturers, is also required to be able to design learning that is oriented towards active student involvement and is expected to stimulate students to be able to think critically and solve the problems they face [1]. Critical thinking skills are very important for a student to have which can be used as a basis for solving problems at any time, especially for students after completing their studies at university. This includes scientific activities such as asking questions, making statements, choosing the right option, and making decisions in chemical experiments [4].

One alternative that can be applied to improve students' critical thinking skills, including in chemistry learning, is problem-based learning. Problem Based Learning (PBL) is a model that is suitable for creating a good learning environment and preparing students to think critically, analytically and discover using various sources [5]. The main goal of the PBL model is to develop critical thinking and problem solving skills, as well as developing students' ability to actively build their own knowledge [6]. Several studies also show that the PBL model is influential and can improve students' thinking skills [3, 5-12], understanding science concepts [13], problem solving abilities [14], and can improve student learning outcomes [15-16].

The rapid development of science and technology also requires educators to be able to prepare students who are able to think critically and are competent in various fields, namely Science, Technology, Engineering, Mathematics (STEM). STEM includes processes of critical thinking,

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analysis and collaboration where students integrate processes and concepts in the real world context of science skills and competencies for college, career and life [17]. The STEM learning approach is an integration of science, technology, engineering, and mathematics learning that is recommended to help achieve 21st century skills. This means that through the STEM approach students do not just memorize concepts, but rather how students understand and comprehend scientific concepts and their relationships in everyday life [18]. Several studies also show that the STEM approach can improve students' critical thinking skills [19-23], improving skills creative thinking [24], and being able to improve student learning outcomes [25, 26].

Students' critical thinking skills cannot be separated from the openness to information factor known as literacy or information literacy [27]. In the 21st century, literacy skills are not only limited to the ability to read, listen, write and speak orally, but more than that, literacy skills are emphasized on literacy skills that are connected to each other in the digital era like today [28]. In the era of digital literacy where the flow of information is very abundant, students need to have the ability to select relevant sources and information, find quality sources and assess sources from the aspects of objectivity, reliability and up-to-date-ness [29]. Chemistry is included in the science family, so chemical literacy is part of scientific literacy. Scientific literacy is multidimensional in its measurement aspects, namely science content, science process, and science application context [30]. Chemical literacy relates to how students can explain phenomena and solve problems in life by using their understanding of chemistry, understanding chemical innovations in social life and having an interest in chemistry [31]. Chemical literacy can be used as a forum for students to practice higher level thinking where students relate it to everyday phenomena [30].

Method

This research aims to develop general chemistry teaching materials using electrochemical material. This research is a type of development research or research and development (R&D), which is a type of research that produces products rather than testing a theory, it is a process used to develop and validate educational products and test the effectiveness of these products. The result of this development research is a PBL STEM model based on chemical literacy to improve students' critical thinking skills in electrochemistry learning.

The development model used refers to the ADDIE development model, with research subjects of 30 students. Data collection techniques and methods in this development research include: (a) Interviews, (b) Validation Sheets, and (c) Test Instruments. The test is arranged according to the competency achieved in electrochemistry learning in the form of a description/essay test to obtain data on students' critical thinking abilities in electrochemical material.

The research data was analyzed in stages to determine the feasibility (validity) and effectiveness of the teaching materials developed. The feasibility (validity) of teaching materials using the PBL STEM model based on chemical literacy is analyzed based on the results of expert validator assessments by considering existing input, comments and suggestions. The effectiveness of teaching materials using the PBL STEM model based on chemical literacy is obtained from the results of students' critical thinking ability tests. The effectiveness of teaching materials is analyzed by increasing students' critical thinking skills (pretest-posttest) using the t-test or paired sample t-test approach with the help of the SPSS program.

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Result And Discussion

The product developed in this research and development is in the form of teaching materials using the PBL STEM model based on chemical literacy in electrochemical material which is intended to make it easier for lecturers and students in the learning process and to improve students' critical thinking skills in electrochemical learning.

Product Validity

The feasibility (validity) of teaching materials using the PBL STEM model based on chemical literacy which was developed in electrochemistry learning, was evaluated and assessed by expert validators based on indicators of suitability for teaching materials from the National Education Standards Agency (BSNP) which were modified according to teaching materials at the university level.

Table 1. Teaching material validation results

Assessment Aspects	Validator (average score)			Total Average	Criteria
	I	II	III		
Content materials	4.50	4.38	4.75	4.54	Valid
Presentation of materials	4.50	4.63	4.25	4.46	Valid
Language	4.50	4.83	4.50	4.61	Valid
Use of learning models	4.80	4.80	4.80	4.80	Valid
Chemical literacy	4.63	4.88	4.75	4.75	Valid
Evaluation and assessment	4.67	4.50	4.83	4.67	Valid
Graphics	4.58	4.58	4.67	4.61	Valid
Average validation results				4.63	Valid

Table 1, shows the results of the assessment by expert validators and obtained an overall average validation result of 4.63 or declared to have met the valid criteria. Thus, it is concluded that General Chemistry teaching materials with a PBL STEM model based on chemical literacy are classified as valid assessed from the aspects of material content, material presentation, language, use of learning models, chemical literacy, evaluation and assessment as well as graphic aspects and are suitable for application in the process. electrochemistry learning.

Achievement of Students' Critical Thinking Ability

Achievements of students' critical thinking skills were obtained through essay tests given to students before (pretest) and after (posttest) learning actions were carried out by implementing General Chemistry teaching materials with a PBL STEM model based on chemical literacy, which had been produced.

Table 2. Results of student critical thinking ability achievements

	N	Min	Max	Mean	Std. Deviation	Kolmogorov-Smirnov test	
						Statistic	Sig.
Pretest	30	50	59	54.33	2.412	0.143	0.119
Posttest	30	74	92	83.27	4.934	0.137	0.155

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Table 2, shows the pretest results of students' critical thinking abilities before being given action. The pretest average was 54.33±2.412 and the data had a normal distribution with a Kolmogorov-Smirnov test (K-S test) value of 0.143 (p=0.119). After carrying out electrochemical learning actions using teaching materials with a PBL STEM model based on chemical literacy, the post-test results showed that the average post-test score for students' critical thinking ability was 83.27±4.934 and the data had a normal distribution with a K-S test of 0.137 (p=0.155).

Effectiveness of PBL STEM Model Based on Chemical Literacy

The effectiveness of the product in the form of General Chemistry teaching materials with a PBL STEM model based on chemical literacy in electrochemistry learning is determined from implementation data based on the achievement of increasing students' critical thinking abilities. The effectiveness of improving students' critical thinking skills was analyzed using a paired sample t-test approach using the SPSS program.

Table 3. Results of student critical thinking ability achievements

	Paired Differences		t	Sig.
	Mean	Std. Deviation		
Posttest-Pretest	28.933	6.654	23.818	0.000

Table 3, shows the results of the analysis of increasing students' critical thinking abilities with the difference in the average value of students' creative thinking abilities (posttest-pretest) of 28.933±6.654 and the results of statistical hypothesis testing obtained a t-count value of 23.818 ($p=0.000 < 0.05$) . Thus, it is concluded that the implementation of General Chemistry teaching materials with a PBL STEM model based on chemical literacy has proven to be significantly effective in improving students' critical thinking skills in electrochemistry learning.

The development of educational products in the form of General Chemistry teaching materials using the PBL STEM model based on chemical literacy in electrochemistry learning was carried out by referring to the ADDIE development model. The results of the expert validator's assessment of teaching materials using the PBL STEM model based on chemical literacy have been declared valid and concluded to be suitable for implementation in the electrochemistry learning process. Validity is met qualitatively based on the assessment of expert validators based on indicators from the National Education Standards Agency (BNSP) with modifications according to teaching materials at university level and according to research objectives, including appropriateness of material content, material presentation, language, use of learning models, chemical literacy, feasibility of evaluation and assessment as well as graphic aspects (average total validation score of 4.63).

At the implementation stage, the use of General Chemistry teaching materials with a PBL STEM model based on chemical literacy in the electrochemistry learning process was also proven to be effective in improving students' critical thinking skills in electrochemical material. Effectiveness is met statistically based on the increase in students' critical thinking ability scores in completing the test, namely based on pretest data before the learning action is given and post-test data after the learning action is completed. Student responses to General Chemistry teaching materials in electrochemical material with the PBL STEM model based on chemical literacy are

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also very positive and are able to train chemical literacy skills and improve students' critical thinking skills.

Conclusion

This research and development produced educational products in the form of General Chemistry teaching materials (books) using the PBL STEM model based on Chemical Literacy on Electrochemistry material which has been declared valid (feasible) to be applied to electrochemistry learning. Validity is met both in terms of appropriateness of material content, presentation of material, language, use of learning models, chemical literacy, evaluation and assessment as well as appropriateness of graphics according to BSNP with modifications in accordance with teaching materials at university level. Implementing teaching materials using the PBL STEM model based on chemical literacy in electrochemistry learning has also proven to be effective in improving students' critical thinking skills with an average increase or difference in post-pretest scores of 28.933 ± 6.654 and proven by the results of statistical hypothesis testing with a probability value (p) =0.000 < 0.05.

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Development of interactive teaching materials based on inquiry based learning (IBL) models based on the outcome-based education (OBE) curriculum in analytical chemistry learning

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Abstract: *This research to develop an Inquiry Based Learning based electronic e-module integrated with the Outcome Based Education curriculum in analytical chemistry learning. This research is a developmentresearch using the ADDIE model which consists of 5 stages: Analysis. Design, Development, Implementation and Evaluation. The sampling technique uses purposive sampling as many as 28 preservice chemistry teachers. Research data were obtained from a validation questionnaire for media experts, material experts, linguists and student responses to the developed e-module with BSNP criteria. Material expert validation obtained an average content feasibility of 3.22, language eligibility 3.52 and presentation feasibility 3.73 IT expert validation obtained an average for design indicators 3.75, display 3.75 and visual 3.3 and usage 3.75. Student response to learning using an electronic IBL-based e-module integrated with the OBE curriculum for display is 89.99%, content quality is 92.85%, usage is 93.3% and usefulness is 93.15%.*

Keywords: IBL, OBE, valid and effective e-modules, analytical chemistry

Introduction

The quality of education in Indonesia at that time was still relatively low. According to data from the National Development Program (UNDP) on the 2020 Human Development Index (HDI) value,

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Indonesia ranked 107th out of 189 countries. Although there is an increase year by year, as shown by Indonesia's consecutive HDI value of 0.703 in 2016; 0.707 in 2017; 0.712 in 2018; 0.718 in 2019; and 0.718 in 2020, however this increase is still not significant and tends to level off [1]. Since the HDI value is understood as a measure of progress in the quality of education, health and income of a country, this stagnant trend shows that the quality of education in Indonesia is as good as ever, lower previous years. This certainly needs the attention of many parties

Based on the results of case studies carried out at universities in North Sumatra in the courses Basic Analytical Chemistry and Qualitative and Quantitative Analytical Chemistry over the past two years, this is not optimal. This is known because the final exam results of chemistry teachers in training only achieved 12.62% A points, 10.19% C points and 4.85% E points. Regarding this issue, efforts should be made capacity to improve learning quality with competent learning models. Equip and activate pre-service chemistry teachers' knowledge so they can foster thinking skills and consolidate concepts to acquire basic skills in analytical chemistry. Therefore, the ability of future teachers to think creatively, critically, collaborate, and communicate can be trained in a scientific attitude when exploring facts, concepts and theories as well as educating on outcomes (OBE) [2,3].

Efforts that could be made to overcome this problem include providing e-modules based on inquiry-based learning integrated into the OBE curriculum. Interactive electronic modules can increase students' learning interest to improve their learning outcomes [4]. Electronic modules can be studied independently so that students become more active [5,6]. Additionally, e-modules are also interactive and can present material using multimedia displays such as videos, animations, simulations, tests allowing direct feedback [7].

Outcome-Based Education (OBE) is an education that focuses on outcomes, not just documents to be completed. OBE measures learning outcomes (outcomes) and allows students to develop new skills that prepare them globally [8,9]. With interactive e-modules based on inquiry-based learning according to the integrated concept of a valid, effective and practical Outcome-Based Education (OBE) program, students will be proactively motivated more interactive, collaborative and innovative in building their knowledge and skills, so that students' skills will increase as graduates who are superior, qualified, productive, capable learning management capacity and capacity with a responsible attitude at work to become a professional teacher.

The research stages carried out are (1) The need for analysis, curriculum analysis and analysis of educational materials needs to be developed; (2) Design and develop interactive electronic modules; (3) Confirmed by media validation experts; material validation experts; confirmation by experts/speakers in the field of KDBK analytical chemistry; (4) Modify the product based on the results of the previous validation phase until an interactive electronic module educational material based on a valid inquiry-based learning activity is obtained according to the revised BSNP standards change; (5) Implementation and (6) Evaluate.

Methodology

This type of research is Educational Research and Development, using the ADDIE method.This research is planned for one year and will be carried out at the Department of Chemistry, Medan State University.

The development model used is ADDIE which includes 5 phases: Analysis, Design, Development, Implementation and Evaluation. This study was conducted at Unimed Department of Chemistry from March 2023 to November 2023. The sample of this study included 28 preservice chemistry teachers in training. Sampling was carried out using the purposive sampling method. Data Analysis Techniques Professional Review Panel Validation Test of Documentation and Media Aspects with BSNP Standards

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and Student Feedback Questionnaire. To find the increase in academic performance can be calculated using the formula g coefficient or standardized attainment score [10].

Results and Discussions

Result

The results of the research based on the ADDIE research model can be described as follows.

Analysis Stage

The first step in studying the ADDIE model is analysis. At this stage, it aims to identify the problems that teachers encounter in the learning process. The analysis was performed for the purpose of finding information related to the use of teaching aids, learning models, and learning results in Analytical Chemistry during learning activities. The data obtained during the initial analysis was carried out by interviewing two chemistry professors in Unimed. The first analysis of the results of interviews with chemistry teachers is presented in.

Based on the above explanations, it is necessary to develop electronic teaching materials based on inquiry teaching to improve the learning outcomes of students in Analytical Chemistry. This is also consistent with the opinion that two chemistry teachers said that it is necessary to develop electronic inquiry-based learning teaching materials to motivate students according to their needs. Then, in the stage of analysis the needs of preservice chemistry teachers, the researcher distributed a questionnaire to collect information about students' interests in learning analytical chemistry, learning methods, and difficulties, encountered, teaching materials and the introduction of electronic modules so that teaching materials can be developed according to student needs. The questionnaire was submitted as a Google form.

According to the results of the questionnaire, it can be seen that the teaching materials used most by teachers and students in the learning process are textbooks. Up to 64% of students have never seen and used electronic modules and 50% of students have never used electronic modules during their studies. Based on the above data, it is necessary to develop e-learning modules based on inquiry-based learning. This is also consistent with the results of the initial analysis of teachers' needs, so developing e-learning modules based on inquiry-based learning can improve learning outcomes in chemistry. Analytical learning and motivating teachers for student learning.

Design Stage

Based on the results of the initial analysis phase, this research continued to the electronic module product design phase based on an inquiry-based learning approach. At this stage, some of the activities carried out by researchers are:

a) Select applications that support on-demand learning creation electronic module. The application used is web-based
b) Develop an initial e-module format based on inquiry-based learning. The initial format or design of the electronic module is presented in the form of a diagram. Creating a diagram is intended to provide the developed product with a clear navigation flow and make it easier for users to use.
c) Collect references related to analytical chemistry literature as content of developed electronic inquiry-based learning modules. The equipment used is gravimetric, volumetric titration, acid-base titration, redox titration, precipitation titration and complex titration.

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d) Develop electronic module designs and functions based on inquiry-based learning. The layout of the design and functionality is adapted to the characteristics of a good electronic module that meets the three requirements of didactic, constructive and technical.

Development Stage

At this stage, the researcher develops the product in accordance with what was done at the design stage. The application used to create this educational material is web-based. This link can be accessed using laptops, smartphones and notebooks so that it can be done anywhere and at any time without being limited by space and time.

Then, the developed inquiry-based electronic learning module products will be evaluated for feasibility or tested for compatibility by two chemistry education professors, a materials expert and an IT chemistry expert. practice, using the validation tools developed by BSNP. Suggestions and comments made by the validator during validation testing are used as documentation to improve or modify the initial product so that the final product is considered feasible for implementation in learning [11].

Results of e-module Product Validation by Material and IT Experts

The evaluation of the electronic module is carried out by documentation experts including aspects of content feasibility, language eligibility and presentation feasibility. The experts who certified the documents were two professors from the Unimed Chemical Education Agency. Specifically, the materials expert's assessment can be seen in Figure 1.

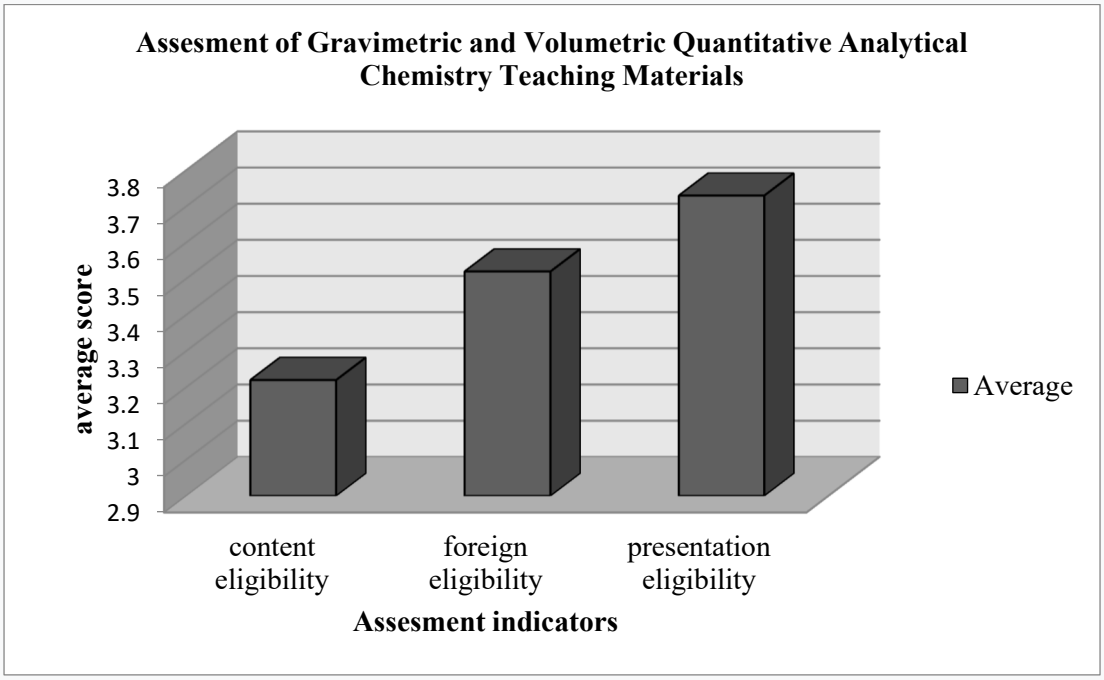

Figure 1. Assessment of the validation of teaching materials by the validator

Evaluations by IT experts include design, visual appearance and usability. Specifically, the IT expert's assessment results can be seen in Figure 2.

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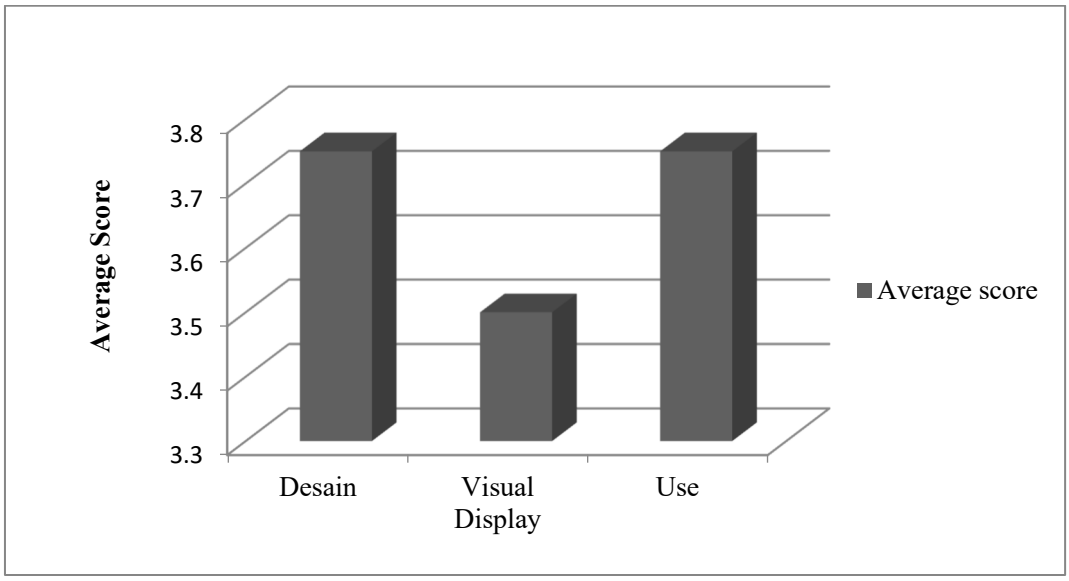

Figure 2. Validation assessment by IT experts

Based on the results of the above evaluation carried out by IT experts, it can be concluded that the developed product is suitable for use in the next phase.

Product Development Results e- module

An e-learning module based on an inquiry-based learning approach has been developed that can be used based on the validation results of document validators and IT experts. The following section presents the final results of the development of the electronic inquiry-based learning modules with link: https://dwndnt.github.io/Modul_kimia_analitik/ The exterior appearance of the housing and back of the developed electronics module is shown in Figures 3 and 4 below.

Figure 3. The front cover of the developed e-module

Figure 4. The back cover of the developed e-module

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Implementation Stage

Once the product is classified as valid and suitable for use based on the endorser, the researcher can proceed to the implementation phase at Faculty of Mathematics and Natural Sciences, Department of Chemical Education, even in the 2022/2023 semester PSPK 21D and up to 28 preservice chemistry teacher who are taught using electronic modules based on an inquiry-based learning approach. First, a pretest was administered to determine students' initial level of knowledge in quantitative, gravimetric, and volumetric analytical chemistry. However, in the past, the pre-test question tool provided was validated and tested first.

In the large group test, 28 chemistry students were conducted. Improved student learning outcomes can be seen through N-Gain. The effectiveness of the electronic module's interactive teaching materials was obtained from the learning results and analyzed using SPSS 12]. The test result data are shown in Table 1 and Figure 5 below.

Table 1. The average N-Gain is normalized in the e-module implementation

Group	Average		N-*Gain*	Criteria
	Pre-Test	*Post-Test*		
PSPK 21D	44,89	89,64	81,20	High

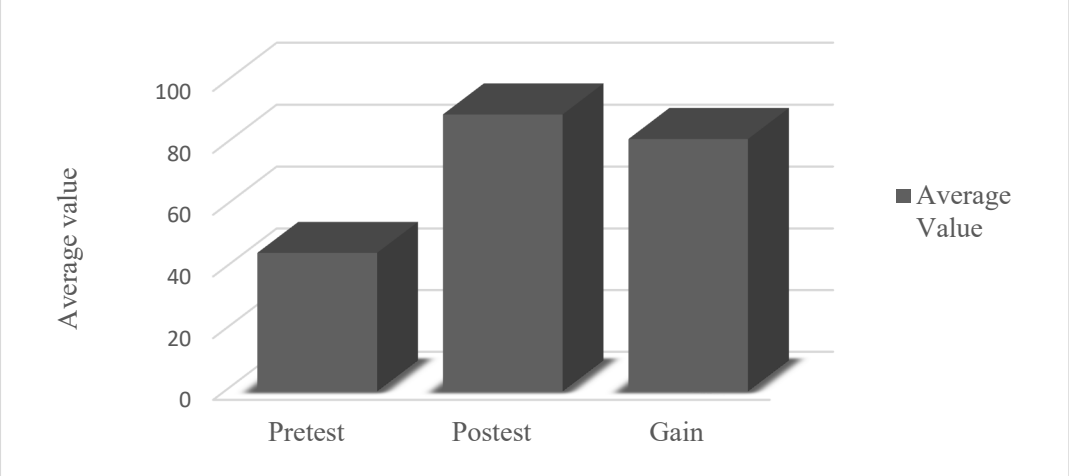

Figure 5. Average student learning outcomes

Results of Perceptions of Student Satisfaction Levels on the application of materials interactive e-Module teaching based on inquiry based learning development results

After students have used the instructional materials in the interactive electronic inquiry-based learning module, the next step is to complete a questionnaire to determine student satisfaction with using the interactive electronic module. The perceived uptake of student satisfaction is summarized by the average percentage value of development results of required learning within the learning range of 89.99% to 93.30% for each report questionnaire module and overall, average student satisfaction in terms of percentage achieved is 92.32%

Conclusion

Educational material on Analytical Chemistry, Gravity Measurement and Volume Measurement in the form of interactive e-modules based on inquiry-based learning designed and developed

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online following the OBE program concept that meets the very valid criteria with a mean validity of 3.66. Interactive electronic module teaching materials based on an inquiry-based learning approach in analytical chemistry and volumetrics that meet the criteria of being highly suitable for use with payer success rates profit (TCR) is 92.32%. Educational materials for analytical chemistry, gravity and volume measurement in the form of interactive electronic modules based on on-demand learning meet the high efficiency target of 81.20%. The value of discovery activities in student learning is assessed at a good level and demonstrates the relevance of the course. Academic Performance Standards (CPMK).

Acknowledgments

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The correlation between chemistry learning outcomes and independent character in the 2022 class student of faculty of mathematics and natural sciences (FMIPA) UNIMED

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Abstract. *This study aimed to investigate the correlation between learning outcomes and the independent character of students using a scientific approach in general chemistry lectures at FMIPA Unimed. This quantitative research involved the 2022 class of FMIPA Unimed students who enrolled in general chemistry courses as the population. The sampling was performed by cluster random sampling, consisting of students of Physics Education, Mathematics Education, Computer Science, and Chemistry Education Study Programs, each taking one class. The instruments test using multiple choice test questions to measure learning outcomes and a questionnaire to determine the character of independent. Both instruments had been validated. The data were analysed using product moment correlation test. The results of data analysis obtained an average of 56.98 learning outcomes and 86.33 independent characters. For each program, the learning outcomes were 56.26; 61.23; 55.77 and 54.50 respectively, while the independent characters were 85.48; 89.76; 84.59; and 85.48 respectively. Pearson correlation test using SPSS 22 showed a significance value of 0.000 with Pearson correlation value of 0.854. For each study program, the significance value is obtained respectively 0.000; 0.044; 0.000 and 0.000 with the Pearson correlation value of 0.885; 0.376; 0.961 and 0.971. This indicated a high correlation between the learning outcomes and the independent character of FMIPA students under scientific approach. The correlations for each study programs are all in the very high category unless the mathematics education study program is in the low category.*

Keywords: General Chemistry, Independent Character, Learning Outcomes, Pearson Correlation, Scientific Approach.

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Introduction

National education has the aim of establishing complete human beings, including qualified in knowledge in order to be able to think critically and creatively, having qualified skills in their fields and having good attitudes or behavior. Education is also a way to realize an active learning process to develop the potential of students so that eventually they become graduates who are capable of competing in the world of the workplace. In the teaching and learning and process, teachers must have a learning strategy so students can learn effectively and efficiently. Education plays an important role in generating quality human resources to build the nation. The achievement of educational goals can be seen based on learning outcomes which have been determined by the value of the minimum achievement criteria so as to show the accomplishment of the educational process that has been carried out.

Learning outcomes are the ability of students to gain knowledge after carrying out the learning process [1] Learning outcomes are the competencies obtained by students after participating in the teaching and learning process which include cognitive, affective, and psychomotor abilities [2]. According to Rusmono [3], learning outcomes are a change in individual behavior including cognitive, affective, and psychomotor domains. Based on this comprehension, it is concluded that learning outcomes are the results that can be obtained from the learning process that has been experienced, assessed and evaluated by the teacher. Learning outcomes have a minimum value standard for being able to be identified the achievement of learning outcomes.

The maximum learning outcomes and exceed the minimum value standards / minimum completeness criteria (KKM) can be achieved by students through effective learning processes and are affected by many factors. One of the important factors affecting learning outcomes is the independence character of the students. Independence is the ability of individuals to behave and solve the problems on their own. According to Masrun, et al (in Patriana, 2007: 21) [4], independent is an attitude which allows a person to be as they wish and do something on their own initiative for their personal needs such as pursuing achievement with perseverance. The Steinberg Aspects of Independence [5] differentiates the characteristics of independence in three types including (1) emotional independence, which is independence that expresses changes in the emotional closeness of relationships between individuals. (2) behavioral independence, which is the ability to make decisions without depending on others and doing it responsibly. (3) value independence, which is the ability to interpret a certain set of principles regarding true and false, and regarding what is important and unimportant.

From the description mentioned above, it can be stated that the character of independence is also part of affective which is the result of learning. The three abilities namely cognitive, psychomotor and affective are very important for the graduates' future. All three of them must be achieved simultaneously. In this research, a correlation study between cognitive ability and independence character will be investigated as a learning outcome by applying a scientific approach. Based on this background, the author wants to analyse the correlation between learning outcomes and the independent character of students.

Methodology

This research is a quantitative analysis to investigate the correlation between learning outcomes and independent character among the students. This research involved a population consisting of all 2022 FMIPA students who were enrolled in general chemistry courses in the 2022/2023 odd

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and even semesters from the physics department (physics education study program, physics study program), the mathematics department (mathematics education study program, mathematics study program and computer science study program) and the chemistry department (chemistry education study program, chemistry study program). The general chemistry course is provided for two semesters. The first semester is specifically for chemistry and biology majors, then the second semester is specifically for mathematics and physics majors. Furthermore, four study programs were chosen by random cluster. The determination of the four study programs was determined based on consideration of the necessity in the offline-online learning trials plan. The selected samples were physics education study program, mathematics education study program, computer science study program and chemistry education study program. The data were collected using test and non-test instruments. The multiple choices test instrument of 15 questions was used to obtain student learning outcomes, while the non-test instrument in the form of a questionnaire of 30 statements was used to obtain data on the character of student independence. Both of these instruments were validated previously. The resulting data were analysed using the Person correlation test with the SPSS 17.0 application program. The level of correlation is determined by the correlation coefficient (r) value with the r value criteria as follows: 0 - 0.49 (weak correlation); 0.5 - 0.79 (moderate correlation); and 0.8 - 1 (strong correlation) [6].

Result and discussion

General Chemistry Learning Outcomes of FMIPA Students

The analysis of learning outcomes used the final exam score of the General Chemistry in the 2022/2023 academic year can be found in figure 1.

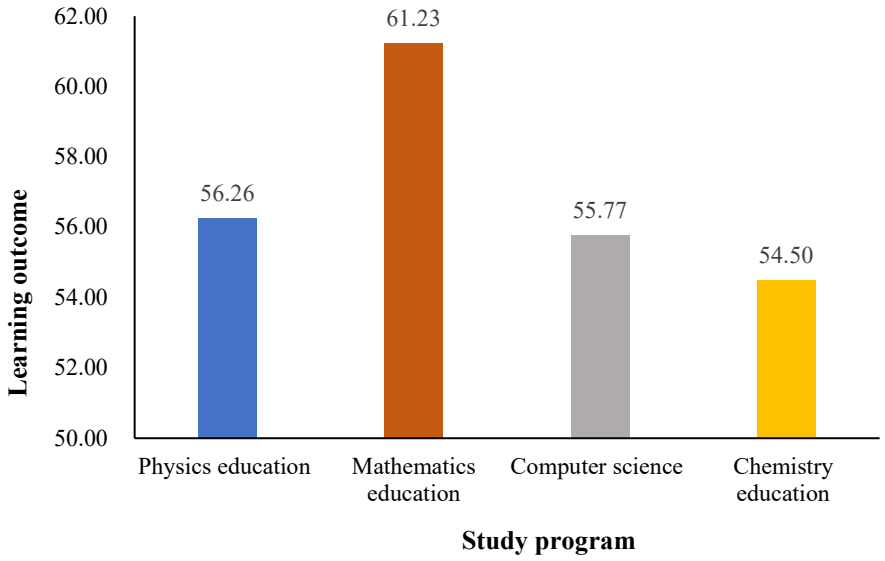

Figure 1. The average of learning outcocme of FMIPA students in general chemistry course

The average learning outcome of the entire 116 sample has a mean value at 56.98 and a standard deviation is 4.929, which indicates no deviation in the learning outcome data and a narrow

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data distribution and a good data deviation. The average results of the General Chemistry Final Examination obtained for Physics Education, Mathematics Education, Computer Science, and Chemical Education Study Programs are 56.26, 61.23, 55.77 and 54.50 respectively. According to the value of learning outcomes, it is summarized that the general chemistry learning outcomes of FMIPA students are in the low category.

Independent Character of FMIPA Students

The data on the independent character of students were obtained from a 30 items questionnaire with a minimum score at 40 and a maximum score at 120. The total average independent character of the 116 sample had a mean of 86.33 and a standard deviation of 4.758, indicating that there was no deviation in the independent character data and the data distribution was small and the data deviation was good. The average character of student independence obtained for Physics Education, Mathematics Education, Computer Science, and Chemical Education Study Programs is 85.48, 89.76, 84.59 and 85.48 respectively. According to the value of learning outcomes, it was concluded that the independent character of FMIPA students was in the high category. The independent character of students can be clearly seen in the following figure 2.

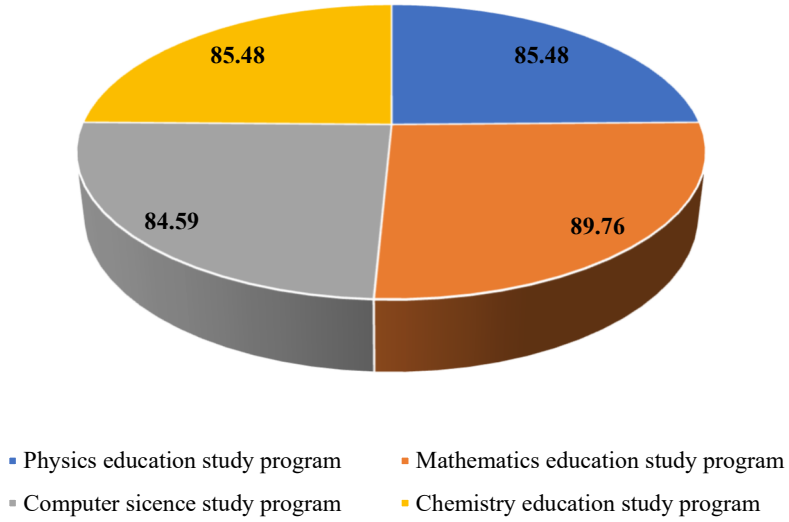

Figure 2. The average of independent character of FMIPA student in general chemistry course

Correlation between General Chemistry Learning Outcomes and Independent Character

Learning outcomes hold an essential role in a learning process. Learning outcomes are the achievements of students in a learning process [7]. The learning outcomes obtained by students were a form of evaluation on the learning process. To determine the correlation between the independent character and learning outcomes, a pre-test was carried out previously, which is the normality test. This test was performed to analyze whether the data is normally distributed or abnormally distributed. The normality test using Kolmogorov-Smirnov was conducted by SPSS. The results of the normality test for the independent character on learning outcomes can be found in Table 1.

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Table 1. Normality test of learning outcome and independent character

Variances	Kolmogorov-Smirnov		
	Statistic	Df	Sig.
Learning outcome	0.057	116	0.200*
Independent character	0.075	116	0.151

As depicted in the table 1, the significance value> 0.05 is obtained, which is 0.057 for learning outcomes and 0.075 for independent character. This indicated that the research data were distributed normally. Subsequently, the homogeneity test of the data was also performed using the Levene Statistic test by SPSS. The results of the homogeneity test can be seen in table 2.

Table 2. Homogeneity test of Variances

Variances	Levene Statistic	df1	df2	Sig.
Independent character	1.123	3	112	0.343
Learning outcome	12.256	3	112	0.163

Based on the table above, the sig value >0.05 is 0.163 for learning outcomes and 0.343 for independent character. It indicated that the research data was homogeneous. Furthermore, the Pearson Correlation test was conducted by SPSS to test out whether there is any relationship between learning outcomes and the independent character as a whole towards the 116 samples. The results of the correlation test can be found in table 3.

Table 3. Correlation test of variances

Variances		Learning outcome	Independent character
Learning outcome	Pearson Correlation	1	0.854**
	Sig. (2-tailed)		0.000
	N	116	116
Independent character	Pearson Correlation	0.854**	1
	Sig. (2-tailed)	0.000	
	N	116	116

**. Correlation is significant at the 0.01 level (2-tailed).

According to the data above, the significance value is 0.000 with a Pearson Correlation value at 0.854. It shows a very high correlation between the learning outcomes and the independent character of FMIPA students under scientific approach. Furthermore, the correlation test between learning outcomes and the independent character of each study program was conducted with the results as in the following table from table 4 to 7.

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Table 4. Correlation test of variances in physics education study program

Variances		Learning outcome	Independent character
Learning outcome	Pearson Correlation	1	0.885**
	Sig. (2-tailed)		0.000
	N	29	29
Independent character	Pearson Correlation	0.885**	1
	Sig. (2-tailed)	0.000	
	N	29	29

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5. Correlation test of variances in mathematics education study program

Variances		Learning outcome	Independent character
Learning outcome	Pearson Correlation	1	0.376*
	Sig. (2-tailed)		0.044
	N	29	29
Independent character	Pearson Correlation	0.376*	1
	Sig. (2-tailed)	0.044	
	N	29	29

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6. Correlation test of variances in computer science study program

Variances		Learning outcome	Independent character
Learning outcome	Pearson Correlation	1	.961**
	Sig. (2-tailed)		.000
	N	29	29
Independent character	Pearson Correlation	0.961**	1
	Sig. (2-tailed)	0.000	
	N	29	29

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7. Correlation test of variances in chemistry education study program

Variances		Learning outcome	Independent character
Learning outcome	Pearson Correlation	1	0.971**
	Sig. (2-tailed)		0.000
	N	29	29
Independent character	Pearson Correlation	0.971**	1
	Sig. (2-tailed)	0.000	
	N	29	29

**. Correlation is significant at the 0.01 level (2-tailed).

The table shows that the significance value for Physics Education (table 4), Mathematics Education (table 5), Computer Science (table 6) and chemistry Education Study Programs (table

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7) were 0.000; 0.044; 0.000 and 0.000 respectively and the person correlation values were 0.885; 0.376; 0.961 and 0.971, respectively. It indicates that there is a correlation between learning outcomes and the independent character for each study programs. The correlations for each study program were all in the very high category with the exception of the mathematics education study program which was in the low category.

Conclusion

Based on the research under scientific approach and demonstrated using SPSS, there is a strong correlation between learning outcomes and independent character. The greater the value of learning outcomes, the greater the value of independent character. Moreover, for all study programs there is a strong correlation between learning outcomes and independent character, except in the mathematics education study program exhibited low category.

Acknowledgments

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Development of project-based interactive e-modules in accordance with the IQF integrated curriculum concept in learning organic chemical reactions to improve student chemistry learning outcomes

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Abstract. P*roject-based interactive learning is the right choice to encourage students to learn actively and effectively, self-centered (student centered) to improve their learning outcomes. The aim of the study was to find project-based interactive e-Module teaching materials that are valid, effective, BSNP standard, feasible to use. Research stages: Needs analysis; project-based interactive e-Module development; standardization validation; individual, small and large group trials; effectiveness test, and test the perception of student satisfaction. Research using the ADDIE method. Sample: IQF-based curriculum, teaching materials from publishers A and B, expert validators and 45 students. Data was obtained using a test instrument to test the feasibility and effectiveness of interactive e-Modules, measure the increase in learning outcomes and student satisfaction. Processed descriptively and analyzed using SPSS. Research findings: interactive e-Module teaching materials as a result of development are valid, standardized, feasible to use. The product has an effective impact on small group trials with student learning outcomes of (M 79.35%), large groups (M = 79.85 %), all categories are high and effective. Respondents' assessment of the product is very valid, feasible to use (M = 3.81). Student satisfaction index is very satisfied (M = 88.80%). Hypothesis testing with paired t-test obtained sig. 0.011. Because sig < α (0.011 < 0.05), there are differences in post-test and pretest learning outcomes. In conclusion, the project-based interactive e-Module teaching materials developed as a result of the development are valid, effective, standardized, and appropriate to be used to help students learn interactively to improve their learning outcomes.*

Keywords: Development of interactive, valid and effective e-Modules, IQF-based curriculum

Introduction

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The application of a curriculum based on the Indonesian National Qualifications Framework (IQF) at TTIs aims to increase the resources for prospective teacher graduates who are superior, qualified, productive, capable and skilled at managing learning with full responsibility as a professional teacher. This is in line with the statement that university graduates in Indonesia are expected to have lives that are able to compete globally as human beings who are superior, qualified, productive, and contribute to the life of society, nation and state [1]

One of the teaching methods that are in accordance with industry 4.0 is the project-based learning method, in which students work independently or collaboratively to solve problems given by lecturers. Chemistry learning is considered as part of basic science, a key to intellectual life and technological developments in science. . Classical barriers between chemistry and basic science cannot be distinguished and gradually overlap with other sciences [2] The actual development of project-based interactive e-Module teaching materials in the Chemistry Education Study Program has not been carried out properly in the application of the integrated curriculum concept of the IQF since 2016 until now. This greatly affects the pattern of teaching courses which are less effective in instilling the IQF integrated curriculum concept with mandatory assignments including routine assignments, critical book reports, critical journal reviews, idea engineering, mini research, and projects.

Based on this, the development of interactive teaching materials needs to be carried out on the basis of the IQF integrated curriculum concept to achieve superior and competitive education. The competence to be achieved is to improve the quality of graduates who are qualified and competitive in learning. Quality competence and competitiveness have an impact on the quality of graduates to be accepted in the world of work and able to play a role in the development of competitive globalization.

Based on data from The Program For International Student Assessment (PISA) study, the achievements of students in Indonesia in the field of science in 2012 ranked 64th out of 65 countries [3]. In 2015, it ranked 62nd out of 70 countries [4] and in 2018 ranked 70th out of 78 countries [5] The low ranking can be seen from the chemistry UN score as part of science, nationally the average national chemistry UN score in 2016 was 55.45 [6]; in 2017 it was 57.80 [7]; in 2018 it was 50.91[8]. and in 2019 it was 50.99 [9]. The acquisition of chemistry scores is relatively low and becomes a challenge for teachers to increase UN scores to reach the specified KKM 7.0. Based on this, it is necessary to increase the chemistry competence of prospective teacher students to produce superior, tough and professional teachers. One of the strategies that can be implemented is through updating learning scenarios that are interactive, practical and effective.

Based on a case study survey of a number of chemistry teachers, they argued that the organic chemistry material, especially the Organic Chemistry Reactions course during their lectures, was still insufficient to equip them to teach organic chemistry at SMA/MA. This is an indicator of the ineffective implementation of the IQF integrated curriculum concept in learning. Based on this, it is necessary to update strategies, methods, models, and learning media so that the implementation of the IQF integrated curriculum concept can be carried out properly so that course learning outcomes (CP_MK) are achieved properly according to learning objectives. One of the media that is suitable for use in learning is project-based interactive teaching material media that can be developed into a project-based interactive e-Module teaching material with reference to the IQF integrated curriculum concept.

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The use of project-based interactive e-Modules will motivate students to be more proactive in learning, because teaching materials can be accessed from the internet at certain times and conditions so that it is not difficult to learn. Interactive E-Modules are designed practically with links and learning flipt videos, so as to attract student interest in learning and create new learning experiences. Likewise, lecturers can easily carry out learning activities even though they are in different places from students. E-learning media facilitates the teaching and learning process, by relying on the internet students become closer to learning, especially when distance learning is implemented [10]. E-Modules are a medium for obtaining material effectively and students can learn according to their abilities and speed [11]. The use of e-modules makes students interested in the learning process, and can be accessed at any time and in any condition, supported by adequate tools so that it is not difficult for students to use them [12]. E-modules are used as learning tools by covering materials, methods, and learning evaluations, designed practically so as to attract student interest in learning [13]

E-Modules are self-instructional, only covering one learning material so that students focus on the material being taught. Adaptive because the development of e-modules is in accordance with the character of students [14]. In developing e-module media, learning models can be integrated by paying attention to their suitability, so that they can make it easier for students to learn[15] The development of electronic learning media can be carried out using the ADDIE method through the stages of Analysis, Design, Development, Implementation, and Evaluation [16].

Project-based learning assisted by e-Module media is collaborative learning based on constructivist theory to achieve the ultimate goal of learning [17]. This model is a dynamic learning approach, students actively explore real-world problems, provide challenges, and acquire deeper knowledge [18]. It has been recommended that equipping teachers with comprehensive knowledge in using new technologies and applying them in the classroom effectively is known as Teacher 4.0 (teachers of the future), who are able to use new technologies and apply them effectively in the classroom [19]. Teachers are responsible for integrating technology in the education system, promoting inquiry, problem solving and students' critical thinking skills [20]. E-Module media-assisted project-based learning has been widely used in Higher Education to improve the quality and effectiveness of teaching [21]. Learning accompanied by project-based practice students will gain increased knowledge, skills and social responsibility in their groups [22]. Based on the research findings [23]. it was reported that with project-based learning assisted by the e-Module, student achievement and learning activities can increase significantly

Methods

This type of research is educational research and development (Educational Research and Development), using the ADDIE method. This research was conducted at the Department of Chemistry, State University of Medan TA. 2023, referring to the Medan State University research strategic plan and the plan to implement the KDBK research in the Unimed Chemistry Study Program. The research stages started from needs analysis, curriculum analysis, analysis of teaching materials to be developed, design and development of interactive e-Modules, validation, revision several times to obtain standard interactive e-Modules products, one-on-one trials, small group trials and large group, implementation and evaluation, such as the flowchart presented in Figure 1

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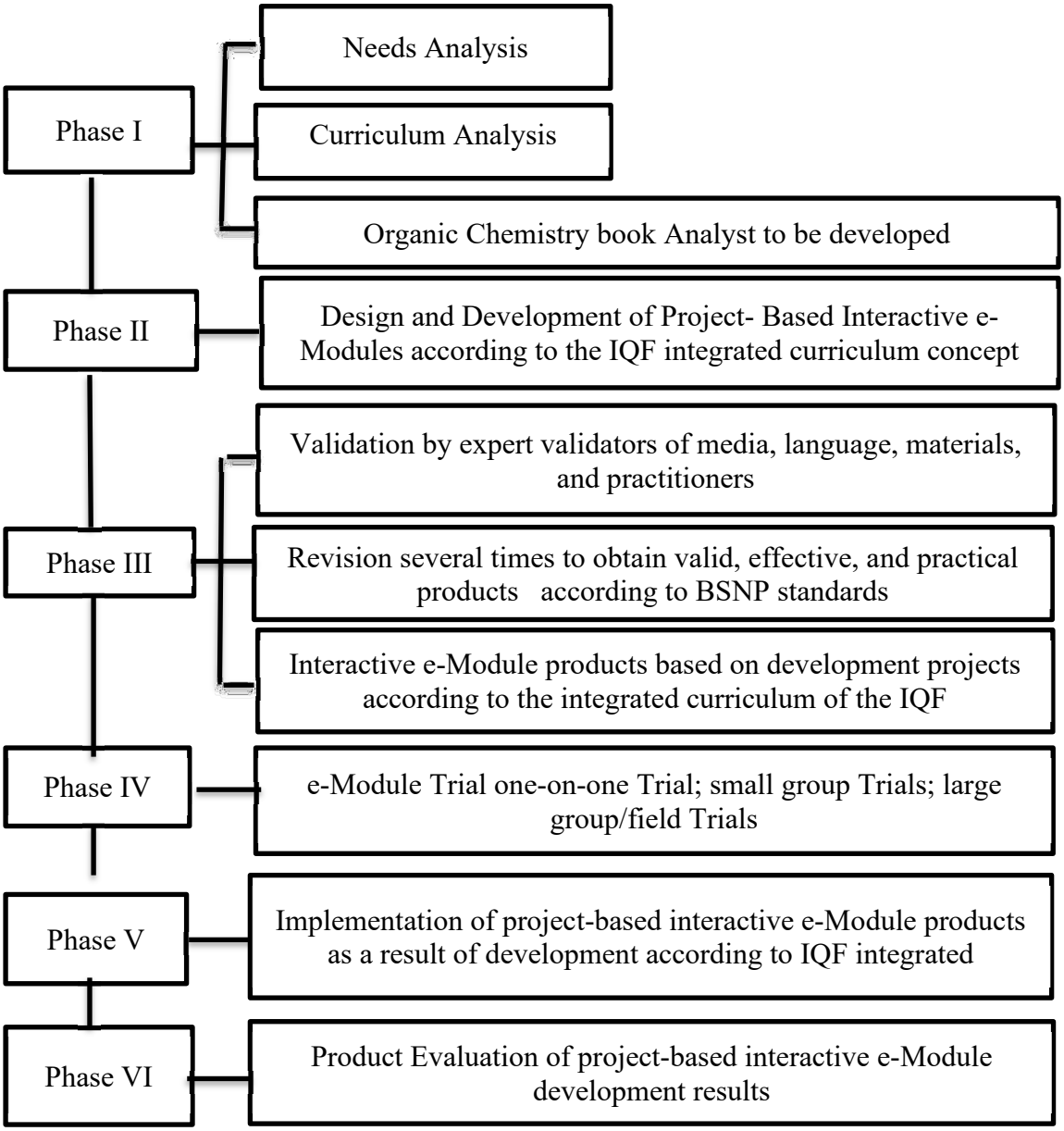

Figure 1. Applied product research flowchart

Data Collection Instruments

The screening instruments and data collection techniques used in the study consisted of: validation questionnaire instruments, learning activity instruments, observation sheet instruments, student satisfaction response questionnaire instruments, learning achievement test instruments. All data collected is collected and distributed into distribution tables for analysis.

Data analysis technique

Analysis of the research data was carried out in a qualitative and quantitative descriptive

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manner on the validity and effectiveness of the interactive e-Module development results. Calculating the average value of validity, the average value of effectiveness, the average value of increasing student chemistry learning outcomes, the average percentage of student satisfaction levels in learning. Data were processed descriptively and analyzed using ANOVA statistical variance assisted by SPSS software.

Feasibility Analysis of Interactive e-Modules

The data analysis technique used to analyze validation data from lecturers and teachers is the average technique with the formula $\overline{X} = \frac{\Sigma X}{n}$; $\overline{X}$ = average value ; ΣX/n = number of validator/test subject assessment answers; Σ X = number of validator/test subject assessment answers; n = number of validators/test subjects : [24] The full range of validation criteria for calculations can be observed in the following Table 1.

Table 1 Average analysis validation criteria

Average	Validation criteria
3.26 – 4.00	Very valid
2.51 – 3.25	Valid
1.76 – 2.50	Less valid (revised)
1.00 – 1.75	Invalid (total revision)

Analysis of Improved Learning Outcomes

To find out the increase in learning outcomes can be calculated by the g factor formula (normalized gain score). Percent increase in learning outcomes is calculated by: gain equal to the value of the posttest score minus the pretest score divided by the maximum score minus the pretest score with criteria: g < 0,3 = (Low) ; 0,3 ≤ g ≤ 0,7 = (Currently) ; g > 0,7 = (Tall)

Data Normality Test

The normality test uses the Chi Square test (x^2) with the provisions: if Chi square (hit.) χ^2 < Chi square $_{(tab)}$ at α = 0.05, the sample is normally distributed.

Homogeneity Test

Homogenity test by calculating F_{count} from the value of the largest variance divided by the smallest variance. If F_{count} < F_{table} at (α = 0.05) (db= (n1-1)(n2-1)), then the data is homogeneous.

Hypothesis test

After the data is normally distributed and homogeneous, a hypothesis test is carried out with one-sided t test (right-hand test), with the criteria: if $t_{count}t > t_{table}$ at the real level (α = 0.05) (db = n1 + n2 –2) then $H_{(a)}$ is accepted and $H_{(o)}$ is rejected

Results And Discussion

The results of research and discussion in this study can be seen as presented below.

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Results of Preliminary Analysis of Organic Chemistry Teaching Materials from publishers A and B

Prior to carrying out research and development, an integrated curriculum analysis of IQF was first carried out and an analysis of organic chemistry teaching materials for publishers A and B to find out their strengths and weaknesses. ,21; linguist 3.02; material expert 3.11; and expert practitioners 3.25; Overall, the average value of content feasibility is 3.12; including valid criteria and does not need to be revised. For language eligibility, the average value of the media expert validator is 3.05; linguist 3.15; material expert 3.20; and expert practitioners 3.15; overall obtained 3.14; including valid criteria and does not need to be revised. For the feasibility of presenting the average value of the media expert validator 3.14; linguist 3.21; material experts 3.13; and expert practitioners 3.08; overall obtained 3.14; includes valid criteria and does not need to be revised. For graphic feasibility, the average value obtained from the media expert validator is 2.78; linguist 3.05; material experts 2.97; and expert practitioners 2.86; overall obtained 2.98; including valid criteria and does not need to be revised. Furthermore, the average final grade for organic chemistry teaching materials from publisher A was obtained at 3.08; meaning that it is in accordance with BSNP standards and is suitable for use by students in learning

Data from the validator's analysis of organic chemistry teaching materials from publisher B were obtained for content feasibility: the average score of the media expert validator was 2.94; linguist 2.85; material experts 2.78; and expert practitioners 2.86; overall obtained 2.89; including valid criteria and does not need to be revised. For language feasibility, the average value obtained from the media expert validator is 3.12; linguist 2.84; material experts 3.16; and expert practitioners 2.95; overall the average value obtained is 3.04; including valid criteria and does not need to be revised. For the feasibility of presentation, the average value obtained from media experts is 2.87; linguist 2.82; material experts 3.06; and expert practitioners 2.89; overall obtained 2.95; including valid criteria and does not need to be revised. Meanwhile, for graphic feasibility, the media expert validator obtained an average value of 2.68; linguist 2.94; material experts 2.86; and expert practitioners 2.67; overall obtained 2.77; including valid criteria and does not need to be revised.Overall, the average final score for Organic Chemistry teaching materials from publisher B was 2.90; meaning that it is in accordance with BSNP standards and is suitable for use by students in learning.

However, when viewed from the IQF integrated curriculum concept, organic chemistry teaching materials from publishers A and B still need to be revised by means of design and development into a teaching material in the form of project-based interactive e-Modules needed by students in the Organic Chemistry Reactions course, so that students can be more motivated to learn it. Weaknesses and deficiencies identified by the expert validator in teaching materials from publishers A and B, namely: Not yet containing the formulation of graduate learning outcomes (CPL) and course learning outcomes (CP_MK) according to the IQF integrated curriculum concept. Teaching materials A and B are not in online form so they cannot be accessed from the internet. Learning flipt videos and links are not yet available. There is a lack of consistency between the sub-material and the subject matter, the presentation of the material is incomplete and there is no mini-research pilot project available according to the integrated curriculum concept of the IQF.

In the effort to develop project-based interactive e-Modules, the presentation of material needed in the organic chemistry reaction course will be made complete and consistent, CPL

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and CP_MK formulas will be included, learning is designed online with links available, has complete learning flipt videos with links. There is a student worksheet (LKM). The order of the sub-material will be adjusted to the subject matter in the scope of material that is expanded with the availability of a laboratory experiment mini-research project, and is accompanied by examples of competency test questions and answer keys. The use of sentences in work procedures will be formulated in such a way as to be easily understood and not allow students to experience misconceptions.

Project-based interactive e-Module Teaching Material Development Results according to the IQF integrated curriculum concept

The deficiencies obtained from the analysis of organic chemistry teaching materials from publishers A and B became the basis for the development of project-based interactive e-Module teaching materials with reference to the IQF integrated curriculum concept, so that BSNP standard teaching materials were produced and suitable for use by students in Organic Chemistry Reaction lectures. In the development stage of project-based interactive teaching materials complete with graduate learning outcomes (CPL) for the Organic Chemistry Reaction course, the course learning outcomes (CP_MK) include knowledge, general skills, specific skills and attitudes, instructions for using teaching materials and concept maps according to the integrated curriculum concept IQF

The teaching materials developed are made into 7 (seven) parts of valid and effective interactive project-based e-Modules, standardized with BSNP, with the main sequence of materials: e-Module-1 the subject matter of Basic Concepts of Organic Chemical Reactions; e-Module-2 Addition Reaction; e-Module-3 Elimination Reaction; e-Module-4 Nucleophilic Substitution; e-Module-5 Enolate and Carbanion; e-Module-6 Electrophilic Substitution; and e-Module-7 on the subject of Free Radicals. All of them are designed and developed into an online project-based interactive e-Module teaching material with links, containing mini research pilot projects, learning flipt videos accompanied by links, containing mini research pilot project assignments, competency test questions and answer keys, as well as student worksheets (MFI).

Results of the validation of interactive e-Module teaching materials based on development results.

Validation of interactive e-Module teaching materials as a result of development is carried out by giving a score to the questionnaire instrument for content feasibility, language, presentation, and graphic feasibility. Using a Likers scale with a score of 4 = strongly agree; score 3 = agree; score 2 = disagree; and score of 1 = strongly disagree.

The validation results obtained an average content feasibility value by the media expert validator of 3.92; linguist 3.91; material experts 3.84; and expert practitioners 3.85; overall the average value obtained is 3.88; including very valid criteria and does not need to be revised. For language feasibility, the average value obtained from media experts is 3.85; linguist 3.78; material experts 3.91; and expert practitioners 3.79; overall obtained an average value of 3.83; including very valid criteria and does not need to be revised. For the feasibility of presentation, the average value obtained from media experts is 3.72; linguist 3.73; material experts 3.83; and expert practitioners 3.76; overall obtained 3.76; including very valid criteria and does not need to be revised. Meanwhile, for graphic feasibility, the media experts obtained an average score of 3.80; linguist 3.68; material experts 3.81; and expert

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practitioners 3.81; overall obtained an average value of 3.78; including very valid criteria and does not need to be revised.

Overall, the average value of project-based interactive e-module teaching materials developed was 3.81, including very valid criteria. This means that it meets the BSNP standards according to the integrated curriculum concept of the IQF, and is suitable for use by students in learning the Organic Chemistry Reaction course.

Some of the advantages and advantages of project-based interactive teaching materials developed results

Some of the advantages and advantages of teaching materials for Organic Chemistry Reaction in the form of project-based interactive e-Modules. the results of the development according to the IQF integrated curriculum concept, namely: CPL and CP_MK formulations have been included according to the IQF integrated curriculum concept. Designed online and has a link, so students can easily access it from the internet at any time and wherever it is used. Contains concept maps and instructions for using e-Modules, arranged sequentially based on the integrated curriculum concept of the IQF with the order of subjects for the Organic Chemistry Reactions course. All e-Modules starting from e-Modules 1 to 7 are made to have concept maps sequentially to help students understand the series of concepts in the organic chemical reactions material they are studying. Each e-Module contains course learning outcomes (CP_MK), both knowledge CP_MK, general skills CP_MK, specific skills CP_MK, and attitude CP_MK. The composition of the teaching materials has been adapted to the concept of the IQF integrated curriculum, each of which is equipped with a competency test and answer key.

All e-Modules have been equipped with learning flipt videos along with their links, so that students will be more motivated to learn, because they can be accessed easily at any time and in certain situations and conditions. Presentation of material is arranged consistently between sub-material and subject matter, contains mini research laboratory experiments, contains competency tests along with answer keys, competency test questions in objective form and essays in the form of assignments for students to work on, contains experimental procedures, learning is designed online using video learning flipt which students can easily access by clicking on the learning video links that are available for each e-Module, so that students will be more interactive and motivated to learn. The presentation is designed based on a mini research pilot project that is contained in a student worksheet (LKM). The use of sentences in work procedures has been made concise and clear so as not to allow students to experience misconceptions. The use of sentences is made concise and clear, practical so that students can easily understand it. The use of sentences has been adjusted with enhanced spelling (EYD). The front cover image is designed in such a way that it reflects the content of the presentation material, and the colors reflect bright rainbow colors according to the color of the content. The coloring has been adjusted to the colors of the rainbow to reflect the color of the content.

The following is comparative data validation results on organic chemistry teaching materials from publishers A and B with project-based interactive e-Module organic chemistry teaching materials developed as presented in Table 2 and graphical diagrams presented in Figure 2.

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Table 2 The average results of the validation values of teaching materials for publishers A and B and project-based interactive e-Module teaching materials as a result of development

No	BSNP criteria	The average value of the validator is a media expert, linguist, material expert, and practitioner expert		
		Publisher's teaching materials A	Publisher's teaching materials B	Developed e-Module teaching materials
1	Content Eligibility	3.12	2.83	3.88
2	Language Eligibility	3.14	3.04	3.83
3	Presentation Eligibility	3.14	2.95	3.76
4	Graphic Eligibility	2.92	2.77	3.78
	Average	3.08	2.90	3.81

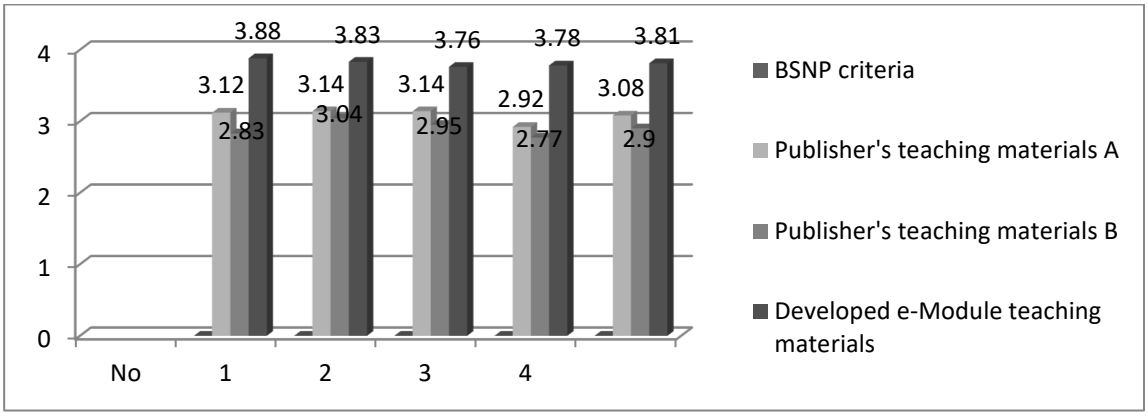

Figure 2 Comparison of the average validation values of teaching materials A and B with interactive E-Modules based on project development results

The following can be seen the cover of interactive organic chemistry reaction teaching materials based on development projects that are designed and developed online on the web: https://dwndnt.github.io/modul_reaksikimiaorganik/mobile/index.html,
and also the web for each e-Module -1 to e-Module-7: https://shorturl.at/mAHY3.
Cover image of the project-based interactive e-Module teaching material resulting from the development of Organic Chemistry Reaction with the link: https://dwndnt.github.io/modul_reaksikimiaorganik/mobile/index.html,
also the cover of each e-Module 1 to e-Module 7 accompanied with learning flipt videos arranged in project-based interactive e-Module teaching materials as presented in Figure 3 below.

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Figure 3 Cover of project-based interactive organic chemistry reaction teaching materials (consisting of e-modules 1 to e-modules 7)

Figure 3a Cover of e-Module-1 and learning flipt video

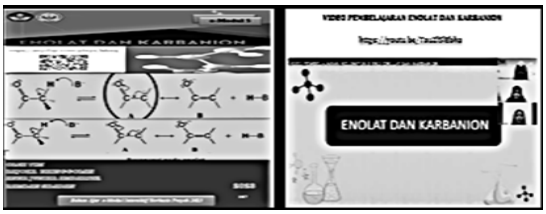

Figure 3b Cover of e-Module-2 and learning flipt video

Figure3c Cover of e-Module-3 and learning flipt video

Figure3d Cover of e-Module-4 and learning flipt video

Figure Cover of e-Module-5 and learning

Figure Cover of e-Module-6 and learning

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3e flipt video **3f** flipt video

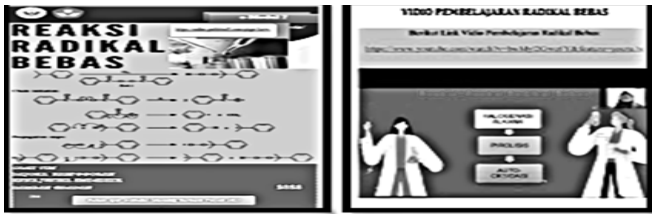

Figure 3g Cover of e-Module-7 and learning flipt video

Trial of interactive e-Module teaching materials based on development results

Trials of interactive e-Module teaching materials based on development projects were carried out three times: one-on-one trials; small group trials; and large group trials or field trials.

One-to-one trial results

The one-on-one trial involved 5 chemistry education students and 2 lecturers. Giving a feasibility score to the respondent's achievement level (TCR). done using the following formula: TCR = (average score)/(ideal score) x 100%. In full, the results of one-on-one trials of project-based interactive e-Module teaching materials developed as a result of the development are presented in Table 3

Table 3 The results of the one-on-one trial feasibility of project-based interactive e-Module teaching materials on the results of the development

No	Aspects of Assessment	Number of Indicators	Average TCR (%)	Category
	A total of 2 Lecturers / Practitioners			
1	Instructional Media	4 Indicator	93%	Very worth it
2	Learning materials	6 Indicator	89%	Very worth it
3	Benefits of e-Module learning media	2 Indicator	95%	Very worth it
	Overall Average TCR		92.33%	Very worth it
	A total of 5 students			
1	Instructional Media	4 Indicator	87%	Very worth it
2	Learning materials	6 Indicator	91%	Very worth it
3	Benefits of e-Module learning media	2 Indicator	89%	Very worth it
	Overall Average TCR		89.00%	Very worth it

Based on the data from Table 3, the results of one trial for the feasibility of project-based interactive e-Module teaching materials developed resulted in an average TCR of 2 lecturers of 92.33%, very decent category, and an average TCR of 5 students obtained 89%, very decent category. Overall, it was obtained 90.67%, the category was very feasible for students to use in learning the Organic Chemistry Reaction course.

Small group trial results

The results of the small group trial involved 10 chemistry education students. The details are presented in Table 4.

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Table 4 Results of small group trials on the feasibility of project-based interactive e-Module teaching materials developed

No	Aspects of Assessment	Number of Indicators	Average TCR (%)	Category
	A total of 10 students of chemistry education			
1	Instructional Media	4 Indicator	91%	Very worth it
2	Learning materials	6 Indicator	93%	Very worth it
3	Benefits of e-Module learning media	2 Indicator	93%	Very worth it
	Overall Average TCR		92.33%	Very worth it

Based on the data in Table 4, it is known that the results of the small group trials on the feasibility of project-based interactive e-Module teaching materials developed resulted in an average TCR of 92.33% in the very feasible category for students to use in learning the Organic Chemistry Reaction course.

Results of large group trials

The results of the large group trial involved 45 chemistry education students. The details are presented in Table 5

Table 5 The results of the large group trial of the feasibility of project-based interactive e-Module teaching materials developed

No	Aspects of Assessment	Number of Indicators	Average TCR (%)	Category
	A total of 45 students of chemistry education			
1	Instructional Media	4 Indicator	93%	Very worth it
2	Learning materials	6 Indicator	95%	Very worth it
3	Benefits of e-Module learning media	2 Indicator	95%	Very worth it
	Overall Average TCR		94,33%	Very worth it

Based on the data in Table 5, it can be seen that the results of the large group trials on the feasibility of project-based interactive e-Module teaching materials developed involving 45 students, obtained an average TCR of 94.33% in the very feasible category for students to use in learning the Organic Chemistry Reaction course.

Test the effectiveness of the developed interactive e-Module teaching materials.

Effectiveness test results in small groups

Testing the effectiveness of small groups of interactive e-Module teaching materials can be seen from the N-gain test by calculating the difference in pre-test and post-test scores, with the formula: N-gain = (S post-test - S pre-test)/(S max - S pre-test) x 100. Then the average gain is calculated to conclude in the high, medium or low category, with an interval scale (gain < 0.3. low; 0.3 < gain ≥ 0.7 moderate; gain > 0 .7 high), then convert to a scale of 100.

The results of the effectiveness test in the small group obtained an average pretest score of

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42.75 and 89.50 posttest. From the calculation, it was obtained an N-gain of 79.35, including in the high criteria, it can be stated that the developed project-based interactive e-Module teaching material product is included in the high effectiveness criteria (very effective).

Then the normality and homogeneity tests were carried out using SPSS with the One-Sample Kolmogorov Smirnov Test analysis technique, at α 0.05. If sig. hits. (sig.) > α, then the data is normally distributed. Meanwhile, the homogeneity test with the One-Way Anova analysis technique is at the level of α.0.05. If sig.hit (sig.).> α., then the data is homogeneous.

Based on the normality test data, the sig. post-test 0.077 and pre-test 0.015, while in Shapiro Wilk for post-test 0.073 and pre-test 0.003. Because of the sig hit value. > α, (0.077 > 0.05) then the data is normally distributed. Furthermore, the homogeneity test was carried out and the sig value data was obtained. for the post test of 0.06. Because sig. 0.06 > 0.05, the data is homogeneous. With the fulfillment of the two conditions for the parametric statistical test, a hypothesis test was carried out using a paired t-test. From the t-test, the Sig. 0.011. Because 0.011 < 0.05 or (sig < α) it can be concluded that there is a significant difference between the post-test and pretest learning outcomes. These results indicate that there is an increase in student learning outcomes before and after learning by 79.35%.

Effectiveness test results in large groups

In the large group trials, the average pretest score was 43.45 and the posttest average score was 89.78. From the calculation, an N-gain of 79.89 is included in the high criteria, so the developed project-based interactive e-Module teaching material product is stated in the high effectiveness criteria. (very effective). Then the data normality test was carried out and the sig value was obtained. post-test 0.077 and pre-test 0.15, while in Shapiro Wilk for post-test 0.073 and pre-test 0.003. Because the sig value > 0.05, the data is normally distributed. Furthermore, the data homogeneity test obtained a sig.based on mean value for the post test of 0.06. Because sig. 0.06 > 0.05, the data is homogeneous. With the fulfillment of the two conditions for the parametric statistical test, a hypothesis test was carried out using the paired t-test formula. From the results of the t-test, the value of Sig. 0.011. Because 0.011 < 0.05 or (sig < α) it can be concluded that there is a significant difference between the post-test and pretest learning outcomes data. These results indicate that there is an increase in student learning outcomes before and after learning 79.89%.

Summary of data on improving learning outcomes in piloting interactive e-Module teaching materials based on development results in small groups and large groups is presented in Table 6 below.

Table 6 Summary of data on improving student chemistry learning outcomes

Data on increasing learning outcomes in trials of project-based interactive e-Module teaching materials developed results				
No	**Sample**	**Mean Pre-test**	**Mean Post-test**	**N- gain**
1	small groups	42.75	89.50	79.35
2	large groups	43.45	89.78	79.89

Based on the data in Table 6, the N-gain in the small group trial was 79.35, meaning that there was an increase in students' chemistry learning outcomes in the small group trial of 79.33%. Meanwhile for the large group, an N-gain of 79.89 was obtained, meaning that there was an increase in student chemistry learning outcomes in the large group trial of 79.89%.

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Graphically it can be seen as presented in Figure 4 below.

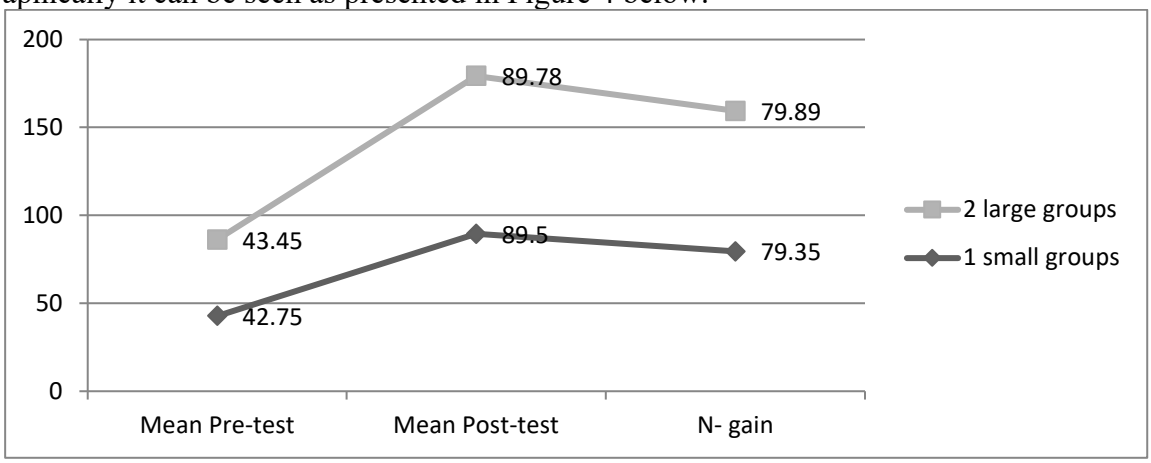

Figure 4 Graph of increased learning outcomes in small and large group trials of interactive e-Module teaching materials based on development results

Results of Perceptions of Student Satisfaction Levels for the application of interactive e-Module teaching materials based on development results

After students use project-based interactive e-Module teaching materials as a result of development in large group trials (field trials), a response questionnaire is given to determine the level of student satisfaction with the use of project-based interactive e-Modules in learning. Questionnaires were given to 45 students to provide responses to 30 items of questionnaire statement indicators. From the completed questionnaire, the amount of data acquisition and the percentage of perceptions of student satisfaction levels were calculated. It was obtained that the average percentage value of the perception of the level of student satisfaction with the project-based interactive e-Module teaching materials developed in learning ranged from 87.47% - 88.80% for each statement questionnaire, and overall the average percentage value was obtained student satisfaction of 88.19%. Based on these results it was concluded that students were satisfied with the use of project-based interactive e-Module teaching materials as a result of development in learning, and could better understand organic chemical reaction material.

Student Performance Assessment Results

Evaluation of student performance was carried out by three observers using a performance assessment instrument, which was carried out during the process of working on a mini-research pilot project in the laboratory and making learning flip videos. Performance appraisal includes 3 (three) components; namely the pre-employment stage, the implementation of learning and the implementation of performance practices. The percentage of student performance scores in project work was obtained by an average percentage of student performance scores in planning and implementing project activities of 85.97%. Based on these results it can be concluded that the performance product of student project activities in learning is classified as good and shows the affordability of course learning achievement standards (CP-MK).

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Conclusion

Based on the data obtained from the research results, several conclusions can be made as follows.

Teaching materials for Organic Chemical Reaction in the form of project-based interactive e-Modules developed online according to the integrated curriculum concept of the IQF are in very valid criteria, very feasible to use with an average respondent achievement rate (TCR) score of 92.44%, and in the criteria high effectiveness (very effective). The application of teaching materials for Organic Chemistry Reaction in the form of interactive e-Modules based on development projects can improve student chemistry learning outcomes in small group trials of 79.33% and large group trials of 79.89% with an average increase in results learning 79.71%. Student perceptions of the use of project-based interactive e-Modules as a result of development are in the criteria of very satisfied with an average percentage score of 88.19%. Student project performance products are in the good category and show the affordability of course learning achievement standards (CP-MK).

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Analysis of the validity and practicality of IBM SPSS statistics teaching materials based on Project-Based Learning (PjBL) on the t-test topic

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Abstract. *The gap between education and the needs of human resources in the world of work and society is an educational problem that occurs in the 21st century. Education today must be able to bridge the gap that occurs through learning innovation, one of which is by implementing the Outcome Based Education (OBE) curriculum in Higher Education. The OBE curriculum emphasizes the achievement of outcomes so that students are expected to have qualified provisions to enter the world of work. The application of the OBE curriculum in learning can be done by using the Project Based Learning (PjBL) learning model and supported by innovative teaching materials. This study aims to produce IBM SPSS Statistics teaching materials based on PjBL based on the Outcome-Based Education (OBE) curriculum on the topic of differential tests that are valid and practical so that they can be useful for lecturers and students in the*

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learning process, especially in Statistics courses. This research is using the Plomp model which consists of five stages, including: 1) Initial Investigation, 2) Design, 3) Realisation/Construction, 40 Tests, Evaluation, and Revision, and 5) Implementation. The validity questionnaire was given to three validators who were selected according to their field of expertise. The validity questionnaire uses three criteria, namely material content, language, and graphics. The practicality questionnaire was given to eight students who had taken the statistics course before. The practicality questionnaire is arranged based on 3 criteria, namely ease of use, presentation attractiveness, and benefits. The results of the data analysis show that the validity of the teaching materials developed is included in the very valid category with an average validation value of 92.98% and very practical with an average practicality value of 91.25%.

Keywords: *Project Based Learning (PjBL), Outcome Based Education (OBE), t-test, IBM SPSS*

Introduction

The rapid development of technology has created a discrepancy between the demands of society and the workplace for human resources and the field of education. The challenge that must be faced in 21st-century education is how to play a role in overcoming the gap between the educational process in higher education and the needs of the world of work. The curriculum in higher education that emphasizes the achievement of outcomes, namely the Outcome Based Education (OBE) curriculum is believed to be able to bridge the gap that occurs.

The OBE curriculum has significant differences from the traditional curriculum. The OBE curriculum is structured based on the needs required by graduates when they work. The learning process does not only emphasize the material that must be completed according to the syllabus like the traditional curriculum but helps students achieve the outcomes that have been determined. The assessment conducted in the OBE curriculum is based on the level of output that has been determined, no longer based on knowledge alone.

According to Davis, M (2001) the OBE curriculum emphasizes innovative, interactive, and effective learning processes. In the OBE curriculum, outcomes or learning outcomes must be identified first, then continue to plan strategies and assessments that are by the expected outcomes. This is very different from traditional learning where usually the topics to be taught are determined by the lecturer first, then based on these topics, the outcomes that must be achieved are arranged. Through the OBE curriculum, students are expected to have qualified provisions to enter the world of work.

The implementation of this outcome-centred OBE curriculum can be done by using the Project Based Learning (PjBL) learning model. According to Zubaidah (2017), PjBL is one of the innovative learning models that is ideal for fulfilling 21st-century education goals. The learning process in PjBL involves four 21st-century competencies, namely critical thinking, communication, collaboration, and creativity. This corresponds with the results of research conducted by Insyasiska, et al (2017) who said that PjBL can encourage students to become more self-reliant in their quest for knowledge (information) from a variety of sources. In PjBL, students are motivated to work with teams to produce creative ideas which are then realized in a product. The PjBL model emphasizes the learning process that has a result in the form of a product where students work on learning projects collaboratively until the results are obtained in the form of a product. Through the PjBL model, it is expected that the learning outcomes can be realized well.

Students taking the Statistics course must be competent to handle research data. Data processing for hypothesis testing in Statistics courses can be done using the IBM SPSS Statistics program. According to Jonathan, S (2006) the advantage of this program is that we can perform statistical calculations quickly from simple to complex ones, which if done manually will take

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longer. According to Syafriani, D (2021), students who use SPSS have 33.5% better practical skills than students who use manual calculations. However, based on the results of the analysis of SPSS teaching materials in circulation, it is known that the existing SPSS modules or guidebooks are still very general, not directly affecting the field of education, especially chemical education. The contents of the guide module or book are in the form of technical how to operate a test without explaining the background of why the test is carried out, how to formulate the hypothesis being tested, and how to interpret the various data that appear in the SPSS output. From the evaluation results in the previous lecture, the teaching materials used have also not been prepared based on PjBL based on the OBE curve.

Based on the background described, it is necessary to conduct research on "Development of IBM SPSS Statistics Teaching Materials Based on Project Based Learning (PjBL) Based on Outcome-Based Education (OBE) Curriculum on Differential Test Topic". The purpose of this study is to produce PjBL-based statistical teaching materials based on the OBE curriculum that are valid, practical, and effective so that they can be useful for lecturers and students in the learning process, especially in Statistics courses.

Methods

This research uses the Plomp model development research which consists of five stages, namely: 1) the Initial Investigation Phase, carried out by analyzing problems or needs such as collecting and analyzing information; 2) The Design Phase, phase aims to design solutions to problems by making work plans or plans; 3) The Realisation/Construction Phase is carried out by production activities such as textbook development; and 4) The Test, Evaluation, and Revision Phase is carried out by the process of collecting and analyzing information systematically to obtain the results of problem-solving; 5) The implementation phase is the implementation stage or the stage of applying the media that has been developed after previous revisions.

The developed teaching materials were measured for validity and practicality. The validity test of teaching materials uses a non-test instrument in the form of a questionnaire prepared based on criteria using a Likert scale of 1-4 given to three expert validators. The validity aspects measured include aspects of material content, linguistic aspects, and graphical aspects. The practicality test of teaching materials uses a questionnaire given to chemistry education study program students who have taken Statistics courses before. The practicality questionnaire uses a Likert scale of 1-4 with three criteria measured, namely aspects of ease of use, presentation attractiveness, and benefits. The validity value and practicality value of teaching materials were analyzed qualitatively and grouped according to the criteria.

Result And Discussion

Development of Statistics Textbook

The development of statistical teaching materials with PjBL-based difference test material based on the OBE curriculum was carried out using the Plomp model which consists of five stages. In detail, the development process is described as follows:

1. *Preliminary Investigation Phase*
   The preliminary investigation phase is carried out for problem definition and planning activities for developing teaching materials for statistics. In this phase, what is done is analyzing the weaknesses of existing teaching materials and reviewing the concepts of good

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teaching materials that will be included in the literature review. Both activities are described as follows:

a. Problem Defining
   In addition to the advantages of existing teaching materials, there are also several weaknesses, including those that are still very general, not directly affect the field of education, especially chemical education. The contents of the guide module or book are technical in the form of how to operate a test without a background explanation of why the test was carried out, how to formulate the hypothesis being tested, and how to interpret the various data that appear in the SPSS output. In addition, the teaching materials are not equipped with detailed pictures of SPSS operating procedures and the teaching materials used have also not been prepared based on PjBL based on the OBE curriculum according to 21st century learning.
b. Planning Research Activities
   From the problems that have been analyzed, the researcher will plan further activities about teaching materials that will be developed into PjBL-based Statistics teaching materials based on the OBE curriculum. The plan that will be made by researchers is about the design of teaching materials for statistics by adding examples of questions that are relevant to educational research, especially chemical education, adding pictures to the procedure for operating SPSS steps, and compiling project assignments based on the OBE curriculum.

2. *Design Phase*

In this phase, researchers made several designs as a solution to the problems that existed in the investigation phase. Researchers carried out designs related to PjBL-based statistical teaching materials based on the OBE curriculum on different test materials. The teaching material implementation plan is designed with components: (a) design of teaching materials, (b) design of images contained in teaching materials, and (c) content design.

Researchers also design research instruments to obtain data about the process and results of the development of teaching materials so that the resulting development is valid, practical, and effective. The instruments designed include 3 types, namely: validity instruments, practicality instruments, and effectiveness instruments. The validity instrument is designed according to the needs in the form of a questionnaire with a Likert scale of 1-4, with the criteria Strongly Agree (4), Agree (3), Disagree (2), Strongly Disagree (1). The validation questionnaire for statistical teaching materials in this study includes three aspects, namely content/material aspects, linguistic aspects, and graphic aspects. Validation of teaching materials was carried out by three expert validators who were selected according to their expertise. The practicality instrument design was made by the teaching materials developed in the form of a student response questionnaire sheet. The observed aspects are display aspects and learning aspects. To measure the effectiveness of teaching materials, an effectiveness instrument in the form of essay questions related to different test materials as many as four questions was prepared.

3. *Realization/Construction Phase*

This phase is a follow-up to the design phase. In this phase, after the product in the form of PjBL-based Statistics teaching materials and supporting devices is designed, the next step will be produced or made. The realization phase can also be said to be the product manufacturing phase. Products that have been made by the design are then said to be prototype 1.

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4. *Test, Evaluation, and Revision Phase*

In this phase, the PjBL-based statistics teaching materials that have been made with different test materials will be validated by expert validators. At this stage, the advantages and disadvantages as well as input from expert validators are seen to improve teaching materials. After validating the teaching materials, tests were conducted in small classes with 8 students. After conducting a series of tests, the next stage is evaluation. Evaluation is carried out to see the extent to which PjBL-based statistics teaching materials based on the OBE curriculum are developed. After the evaluation stage is carried out, the next step will be revision. Revisions are made by looking at the evaluation results. Revisions are also made so that the products developed are suitable for use.

5. *Implementation Phase*

This implementation phase is carried out to conduct trials of PjBL-based statistics teaching materials based on the OBE curriculum that has been made. The trial was conducted on students who were used as research subjects, namely students of the chemistry education study program at the Universitas Negeri Medan.

Validity of Teaching Materials

Three criteria are used in the validation test of instructional materials: language, graphics, and material content. The material content aspect has eight indicators, the language aspect has four indicators, and the graphic aspect has seven indicators. Each indicator has a 1-4 scale value interval where the value of 4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree. The validity value of teaching materials is obtained from the average validation outcomes of the three expert validators. The teaching material validation questionnaire instrument is shown in Table 1. Validation was carried out by three validators who were selected according to their field of expertise.

Table 1. Questionnaire Validation of IBM SPSS Statistics Teaching Materials based on Project Based Learning (PjBL) based on the Outcome-Based Education (OBE) curriculum on Differential Tests Topic

No	Aspects assessed	Score			
		1	2	3	4
	A. Content/Material Aspect				
1	Topics presented in the instructional resources are corresponding with the Course Learning Outcomes.				
2	The material descriptions and examples provided are relevant and attract the attention of students.				
3	Teaching materials contain supporting information that is by the description of the learning material.				
4	Teaching materials are arranged according to Project Based Leaning learning based on the Outcome-based Based Education curriculum.				
5	Examples of problems given following chemical education research can help students understand the material.				
6	Examples of problems provided can help students achieve learning objectives and motivate students to learn.				
7	The reading sources contained in the teaching materials are clear.				

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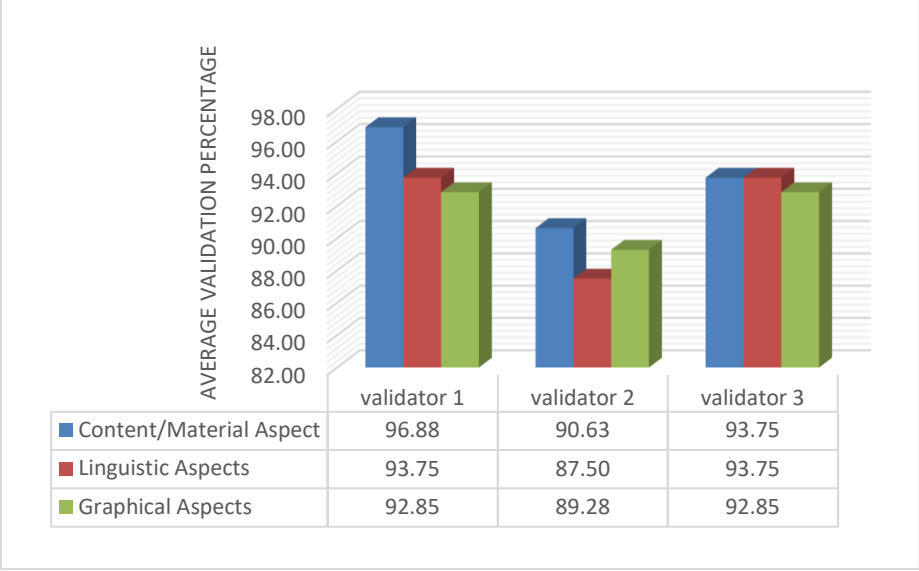
8	Sources of material come from books and other relevant sources
	B. Linguistic Aspects
1	The language used is good and correct according to Indonesian grammar rules.
2	The language used uses appropriate terms
3	The way language is used corresponds with how cognition is developing.
4	Consistent in using terms that describe concepts.
	C. Graphical Aspects
1	The cover design of teaching materials is attractive
2	The size and type of font used in teaching materials are appropriate and can be read clearly
3	The layout of text and images in teaching materials is appropriate.
4	The text layout on the handout is interesting
5	The colors used in teaching materials are appropriate and attractive
6	Teaching materials have a regular layout and layout
7	The structure and arrangement of teaching materials are sequential and systematic

Based on the questionnaire sheet that has been filled in by expert validators, the data is processed and analyzed. The results obtained can be seen in Figure 1. Based on the graph in the figure, it can be seen that from the three aspects of the validation assessment assessed by each validator, the average validation value is 92.98%. This shows that the statistical teaching materials on different test materials developed have fulfilled one of the requirements for the feasibility of teaching materials, namely valid, with very valid criteria. The input submitted by the validator is that the images in the teaching materials (images that come from the SPSS application display) are made with a higher resolution so that they look clearer. Based on this suggestion, the researcher made clearer images with higher resolution.



	validator 1	validator 2	validator 3
Content/Material Aspect	96.88	90.63	93.75
Linguistic Aspects	93.75	87.50	93.75
Graphical Aspects	92.85	89.28	92.85

Figure 1. Recapitulation of Teaching Material Validation Score

Practicality of Teaching Materials

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Practicality is the level of use and applicability of teaching materials by students, namely carrying out learning using teaching materials that have been revised based on validator assessments. A teaching material is said to have a high practical value if the teaching material is practical and easy to use. Data on the practicality of teaching materials is obtained from a questionnaire containing practicality criteria given to students. Assessment of teaching material products based on questionnaire sheets that have been filled in by students is analyzed to assess the degree of applicability of the products developed. Scoring for each indicator uses a Likert scale. The criteria for scoring practicality answers are: 4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree.

The practicality aspects measured in this study include the ease of student users in using IBM SPSS Statistics teaching materials based on Project Based Learning (PjBL) based on the Outcome-Based Education (OBE) curriculum on different test materials using 3 aspects, namely ease of use, presentation attractiveness, and benefits. This teaching material was tested on 8 students of the Chemistry Education S1 study program who had taken Statistics courses. The instrument used for testing is a questionnaire consisting of 20 closed statements. The questionnaire instrument for the practicality of teaching materials can be seen in Table 2.

Based on the results of the questionnaire, the practicality value for the aspect of ease of use of teaching materials is 92.85%, the aspect of the attractiveness of teaching material presentation is 85.00%, and the aspect of the benefits of teaching materials is 91.66%. A recapitulation of the average practicality value of teaching materials can be seen in Figure 2.

Table 2. Practicality Questionnaire for IBM SPSS Statistics Teaching Materials based on Project Based Learning (PjBL) based on the Outcome-Based Education (OBE) curriculum on Differential Test Topic

No	Aspects assessed	Score			
		1	2	3	4
	A. Ease of Use				
1	The use of statistical teaching materials in learning can save time and be efficiently used in learning.				
2	Teaching materials make it easier for students to understand learning materials				
3	Teaching materials make it easier for students to carry out data processing practices.				
4	Teaching materials can be used repeatedly				
5	Teaching materials can be used anywhere				
6	Teaching materials can be used anytime as needed				
7	The description of the material and exercises in the teaching materials is clear and simple.				
	B. Attractiveness of The Presentation				
1	The appearance design of the presentation of teaching materials is interesting to look at				
2	The content of the material in the teaching materials is equipped with illustrations, drawings, and photos that match the material				
3	The size and type of font on the teaching materials are legible				
4	The color combination used in teaching materials is interesting				
5	Context in teaching materials is interesting to read				
	C. Benefits				

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1	Teaching materials help students understand the statistical material of the different test
2	Teaching materials can replace student notes.
3	Teaching materials can be used to study examples of educational research, especially chemical education
4	Teaching materials can add insight into students
5	Teaching materials can help memory knowledge and refinement of the material studied.
6	Teaching materials can be used as an independent student guide to operate SPSS and process data with SPSS.
7	Project tasks in teaching materials make students more capable and skilled
8	Teaching materials can support the 21st-century learning process according to the Outcome Based Education (OBE) curriculum.

Based on Figure 2, it is known that from the three aspects of the practicality assessment assessed by students, the average practicality value is 91.25%. This shows that IBM SPSS Statistics teaching materials based on Project Learning (PjBL) based on the Outcome-Based Education (OBE) curriculum on Differential Test Topics developed are categorized as very practical.

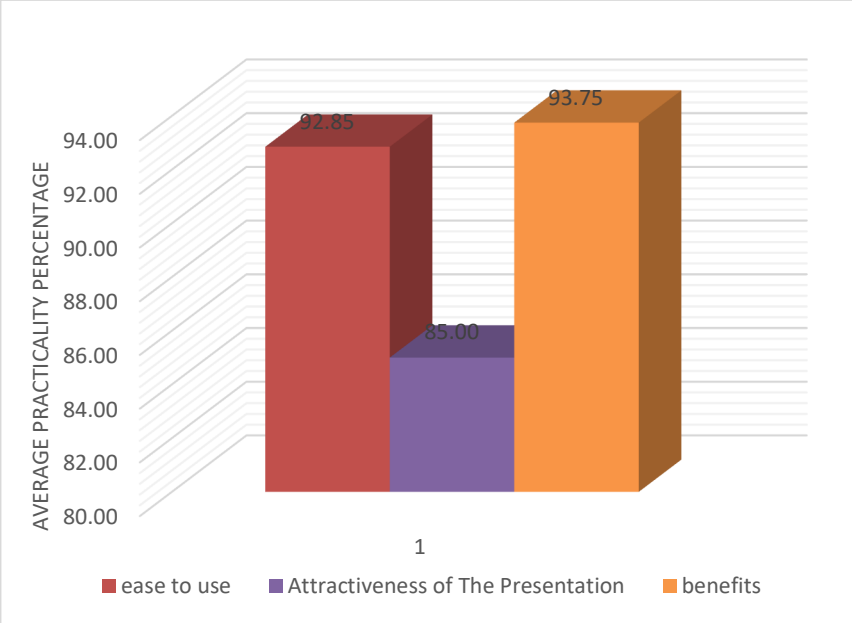

Figure 2. Recapitulation of the Practicality Score of Teaching Materials

Teaching materials developed as a student guide to process research data, especially on the topic of Differential Tests, are arranged by the student's study program, namely chemistry education. The content of the teaching materials begins with an introduction to SPSS and then continues with content related to the topic, namely Differential Test. The examples given in the teaching materials are in the form of research related to chemical education research. The flow in teaching materials follows the syntax of Project Based Learning (PjBL), so students are required to complete projects in teaching materials.

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According to students, the teaching materials developed make it very easy for students to understand the teaching material presented. With the systematic steps equipped with pictures, students can carry out hypothesis testing more independently.

Conclusions

Based on the results and discussion of this research that has been presented, it can be concluded:

1. The validity of IBM SPSS Statistical teaching materials based on Project Based Learning (PjBL) based on the Outcome-Based Education (OBE) curriculum on different test materials is declared very valid with a validation value of 92.98%.
2. The practicality of IBM SPSS Statistic teaching materials based on Project Learning (PjBL) based on the Outcome-Based Education (OBE) curriculum on different test materials is declared very practical with a practical value of 91.25%.

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Development of STEM-PjBL integrated teaching materials on organic compound materials to improve student science literacy

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Abstract. *The demands of learning in the twenty-first century namely, learning chemistry require not only the transmission of knowledge and skills but also the development of higher-order thinking abilities through hands-on experience in the sciences. The ability of teachers to manage engaging, original, and creative learning is essential to raising learning quality. One type of education that can assist 21st-century skills is STEM-PjBL. This study's goal is to determine the validity and practicality of the produced STEM-PjBL integrated teaching materials. This kind of study is called development research. The results of the study show that the STEM-PjBL integrated teaching materials developed are suitable for use with a feasibility value of 93,5 in the very feasible category. The practicality test likewise received an average grade of 4,3 from the lecturer in the very good category and 4,3 from the students in the same category.*

Keywords: Development, STEM-PjBL, organic compound, science literacy.

Introduction

A program called "Education in the 4.0 Era" aims to support the implementation of "smart education" by increasing access to technology-enhanced world-class education and ensuring that all students graduate with at least four 21st-century skills namely collaboration, communication, critical thinking, and creativity referring to global competency standards in preparing young people to enter the reality of global work and 21st-century life [1].

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Science literacy skills among pupils are to be improved by 21st-century education. The PISA study, conducted every three years by the OECD (Organization for Economic Cooperation and Development), can be used to assess students' science literacy. The Program for International Students Assessment (PISA) study's findings indicated that Indonesian students' performance in science in 2003 ranked 38th out of 40 nations [2], 50th out of 57 nations [3], 60th out of 65 nations [4], 64th out of 65 nations [5], and 62nd out of 70 nations [6]. It ranked 70th out of 78 nations in 2018 [7]. Students' inadequate science literacy is a result of several elements in the educational system, including the curriculum, teachers, and students.

Every educator must make efforts to increase the caliber of learning. Today's educational system aims to produce pupils who not only comprehend the subject matter but also possess the necessary competencies. Therefore, managing engaging, creative, and innovative learning requires the imagination of educators. It is anticipated that this will help pupils become more literate in science.

Based on the findings of the observations made, learning resources used in the general chemistry learning process include textbooks, teaching materials containing practice questions, journals, and learning videos. However, STEM-PjBL has not been integrated into the learning process's instructional materials, thus students' levels of science literacy and the capacity for critical thought are still subpar.

21st-century abilities can be acquired through STEM-PjBL education [8]. STEM is a learning approach that integrates four interdisciplines, namely Science, Technology, Engineering, and Mathematics. The benefit of using the STEM method is that it may teach students how to use design expertise to use technology to solve problems related to the environment [9]. In addition, applying STEM can enhance the 4C skills—creativity, critical thinking, collaboration, and communication as well as other skills [10]. STEM-based lessons can enhance students' motivation and learning outcomes in thermochemistry [11]. STEM-based electronic modules are successful at enhancing students' understanding of the material of colligative properties of solutions [12]. The project-based learning paradigm gives lessons that include projects or small amounts of research a higher priority [13].

One type of learning paradigm that raises students' critical thinking abilities is the STEM approach with PjBL [14] so that students are interested and motivated in learning [15]. In addition, students will easily be more understanding of the learning material [16]. The creative and emotional domains, as well as the adventure, curiosity, imagination, and challenge domains, can all be developed through project-based STEM education [17].

It is vital to undertake research in light of the backdrop that has been provided namely "Development of STEM-PjBL integrated teaching materials on Organic Compounds to Improve Student Science Literacy". To improve students' science literacy, This study aims to develop STEM-PjBL integrated teaching materials that are effective and useful in organic compound materials.

Method

This study falls under the category of research and development (R&D). The 4D model is used in this research design. The 4D model includes 4 stages: define, design, develop, and disseminate [18]. There are 5 tasks at the define step, including 1. Front-end analysis. The lecturer performs an initial diagnosis at this stage to increase the efficacy and efficiency of learning. 2. Learner evaluation At this step, the qualities of learners are investigated, such as their aptitude, learning motivation, prior experience, etc. 3. Task analysis: Lecturers identify the key tasks that students

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need to master to meet the minimum skills. 4. Conceptualization Determine the rational course of action to be pursued by analyzing the concepts to be taught. 5) Identifying learning objectives writing learning objectives, anticipated behavioral changes following the use of operational verbs. At the design stage, there are four activities, namely: developing benchmark reference tests, media selection, format selection, and preliminary design. Expert evaluation and developmental testing are the two activities that take place during the development stage. Three tasks are performed at the dissemination stage: validation testing, packaging, diffusion, and adoption.

The data collection techniques in this study were using instrument feasibility sheets and questionnaires. The questionnaires used were material and media expert validation questionnaires, practicality questionnaires, and student response questionnaires. The results of the validation of material and media experts were analyzed descriptively and qualitatively using the feasibility formula. while the results of the practicality questionnaire and student responses were analyzed based on the average score obtained.

Result

In the define stage, an analysis of the issues in the lecture process is carried out by interviews with lecturers teaching the course, students, analysis of course learning outcomes and sub- course learning outcomes, and concept analysis to determine what concepts will be developed in teaching materials related to organic compound materials and determine learning objectives on organic

Front End Analysis

Researchers carried out front-end analysis by interviews with lecturers who teach general chemistry courses on the lecture process, learning models, media, sources used, and students' comprehension of the lecture material. Based on the interviews, it was determined that lecturers continue to concentrate their lectures on going over questions from the textbook or module they are using, STEM-PjBl has not been integrated, especially for organic compound materials, and many lecturers continue to use a student-created presentation system, and there is still a dearth of student-produced projects.

Student Analysis

Researchers analyzed student data by interviews with students in-depth about the lecture process, their interest in organic compound material, and their capacity to connect organic compound material with STEM-PjBL. Based on the interviews, it was determined that there is still a lack of projects involving organic compounds, a high workload during lectures, and students' inability to connect material about organic compounds to other subjects covered by STEM. These factors combine to leave students with poor science literacy skills.

Task Analysis

Task analysis was conducted by researchers by analyzing course learning outcomes and derived into sub- course learning outcomes.

Concept Analysis

Researchers do concept analysis by examining sub- course learning outcomes concepts, and they continue by examining the concepts that will be developed in instructional materials connected to organic chemical material. Alkanes and cycloalkanes, alkenes and alkynes, alcohols and ethers,

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aldehydes and ketones, and carboxylic acids, and esters make up the outcomes of the concept analysis.

Specification of Learning Objectives

The specification of learning objectives is carried out by researchers through the analysis of learning objectives in organic compound material, namely a. Students can draw the concept of the structure of an organic compound b. Students can explain the concepts of structure, name, isomers, physical properties and chemical properties, reactions, manufacture, and use of Alkanes and cycloalkanes c. Students can describe the concepts of structure, name, isomers, physical properties, chemical properties, manufacture, and use of Alkenes and alkynes d. Students can describe the concepts of structure, name, isomers, physical properties, chemical properties, manufacture and use of Alcohols and ethers, etc. Students can describe the concepts of structure, name, isomers, physical properties, chemical properties, manufacture, and use of aldehydes and ketones f. Students can describe the concepts of structure, name, isomers, physical properties, and chemical properties, and manufacture and use of aldehydes and ketones. Students can describe the concepts of structure, name, isomers, physical properties, and chemical properties, manufacture and use of carboxylic acids and esters.

The second stage is the design stage, at the design stage, test preparation, formatting, and initial design are carried out. The study of learning objectives forms the foundation of test preparation. The test is designed to evaluate students' aptitude for learning chemistry, specifically about organic compound material. A grid with cognitive levels C4, C5, and C6 was used to create and develop the test. Times New Roman is used as the typeface for the title and content of the instructional materials, with 1.5 spaces between lines in a column style, and the paper is formatted to the UNESCO standard, which is 15.5 x 23 cm. The information is organized logically and progressively, with a white paper background and a color scheme of orange and blue for the module's contents. The module's initial layout is organized sequentially and includes a cover, preface, introduction, STEM components, usage instructions, course learning objectives, and concept maps. Next, go on to the content section, which includes the material's title and each of its sub-chapters, each of which includes a description of the project tasks (PjBL) that students must complete. The information's subject matter is also connected to other STEM disciplines including technology, engineering, and mathematics. A summary, competency exam, glossary, bibliography, and author biography are included in the final section. The initial design of teaching materials is shown in Figure 1.

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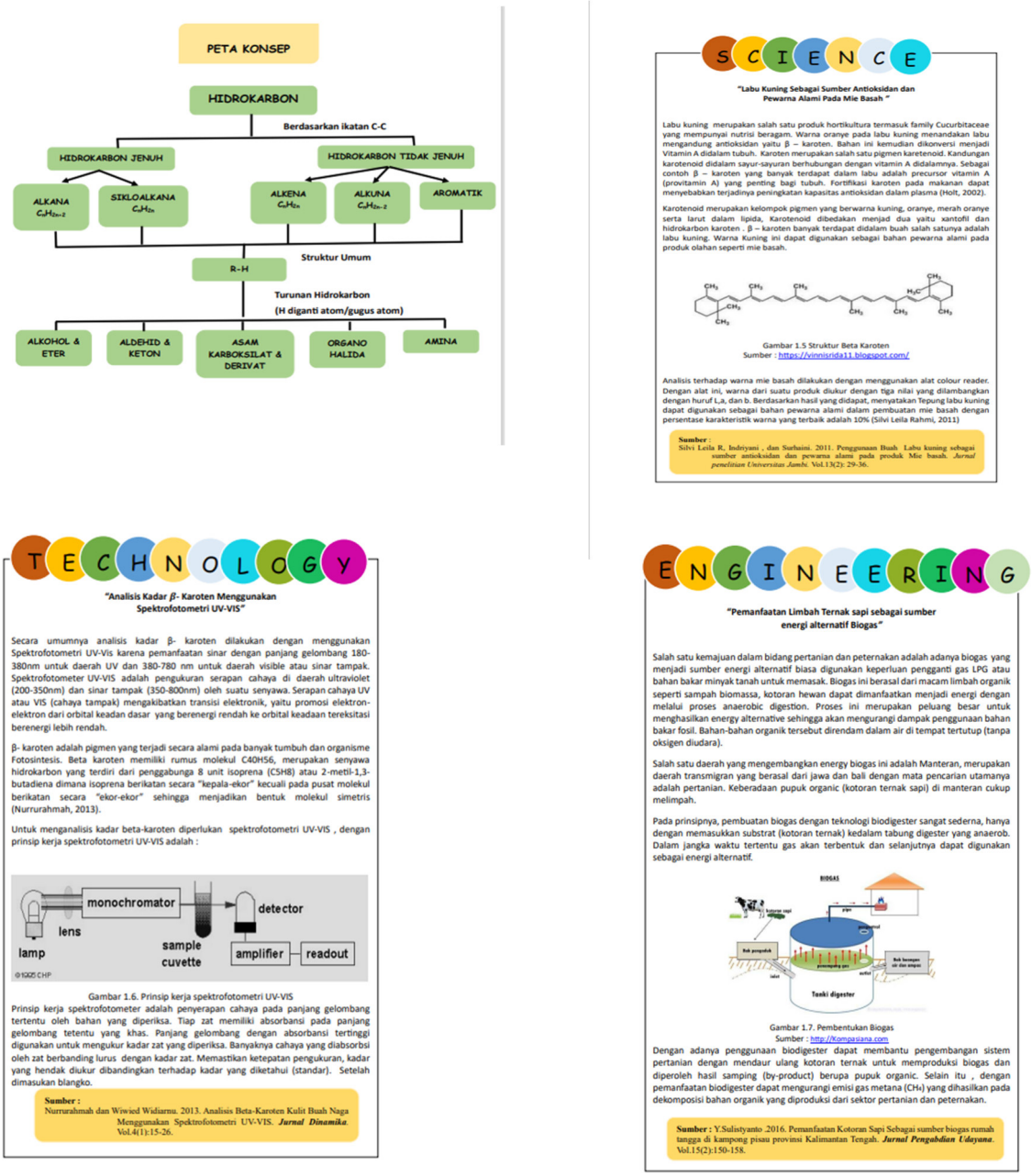

Figure 1. Preliminary design of teaching materials

Validation tests and practicality tests were carried out at the development stage to create valid and practical teaching materials. In revising the teaching materials that have been developed, the validation analysis conducted by media experts and material experts is also taken into consideration.

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Validation of Material Experts

Two chemistry instructors who served as validators for the material under review. Validation utilizing a validation sheet with up to 26 assertions and a score range of 1 to 5 for each item. Aspects of curriculum suitability, material accuracy, clarity of evaluation in teaching materials, accuracy of presentation, suitability with language rules, suitability with the development of science literacy skills, and suitability with science, technology, engineering, and mathematics are some of the aspects of assessment made by material experts. The eligibility formula was used to analyze the findings of each validator's assessment to determine the degree of validity of the created educational materials. Figure 2 displays the data on the feasibility results.

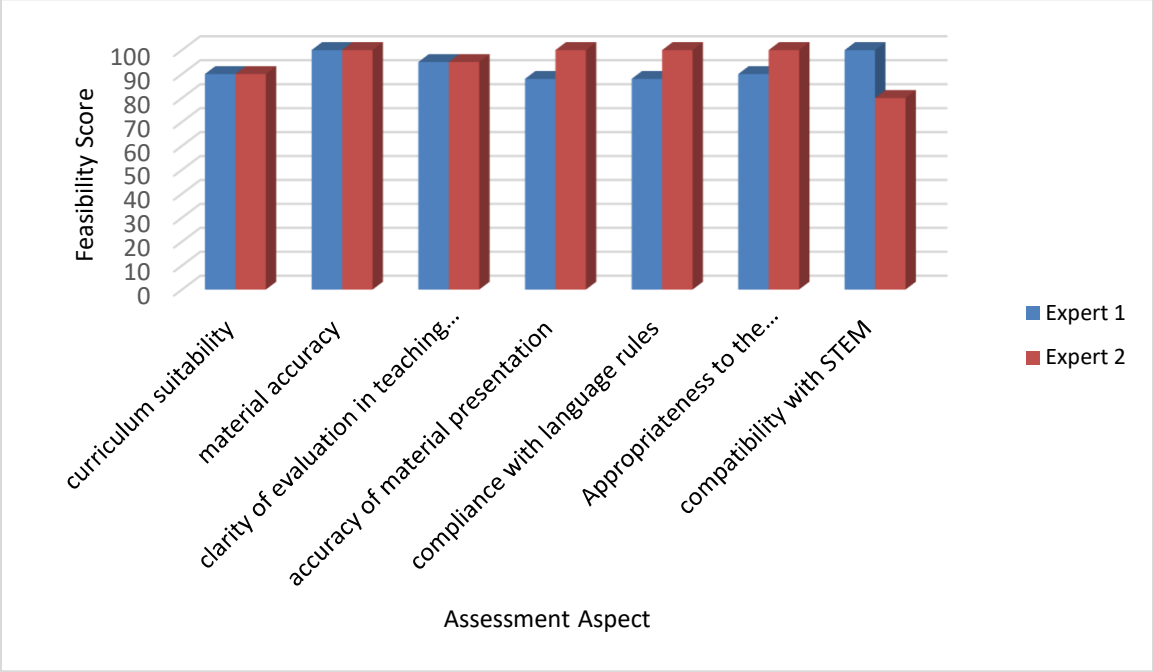

Figure 2. Recapitulation of Material Expert Feasibility Assessment

The graph above shows that of the seven assessment criteria evaluated by each material expert, the average feasibility value is 96 which is included in the very feasible category. This indicates that the STEM-PjBL integrated learning resources developed can be used with a fairly realistic feasibility category.

Validation of Media Experts

By using validation instruments, media specialists validate teaching materials. The evaluation findings are derived from the media expert's completed questionnaire sheet, and the assessment data is then examined using the feasibility formula (P). The eligibility results (P) by two validators shown in Figure 3 are summarized below.

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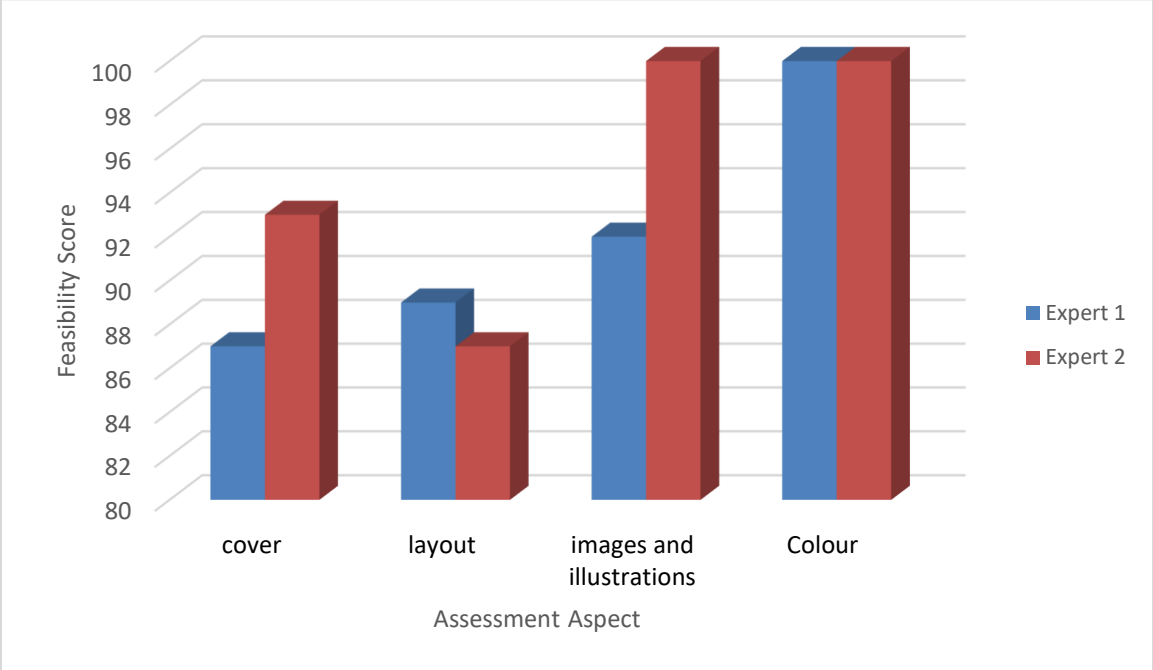

Figure 3. Recapitulation of Media Expert Feasibility Assessment

The graph demonstrates that the average feasibility value for the four assessment criteria—which were evaluated by each media expert is 91, falling into the category of extremely feasible. This demonstrates that the STEM-PjBL integrated teaching materials created can be used with a fairly realistic category of feasibility.

So it can be concluded that the STEM-PjBL integrated teaching materials have been valid based on the assessment of material experts and media experts with a feasibility value of 93.5 very high category.

Practicality of lecturers

Furthermore, an assessment was carried out by 7 lecturers of general chemistry courses to determine the level of practicality of the STEM-PjBL integrated teaching materials developed. A twelve-statement practicality questionnaire with a 1–5 point scale was used for the evaluation. The aspects of assessment by lecturers include aspects of ease of use, estimated learning time, and benefits. To assess the degree of practicality of the created instructional materials, the lecturer's assessment scores were converted to the average value of practicality. The data on the average value of practicality obtained can be seen in Figure 4.

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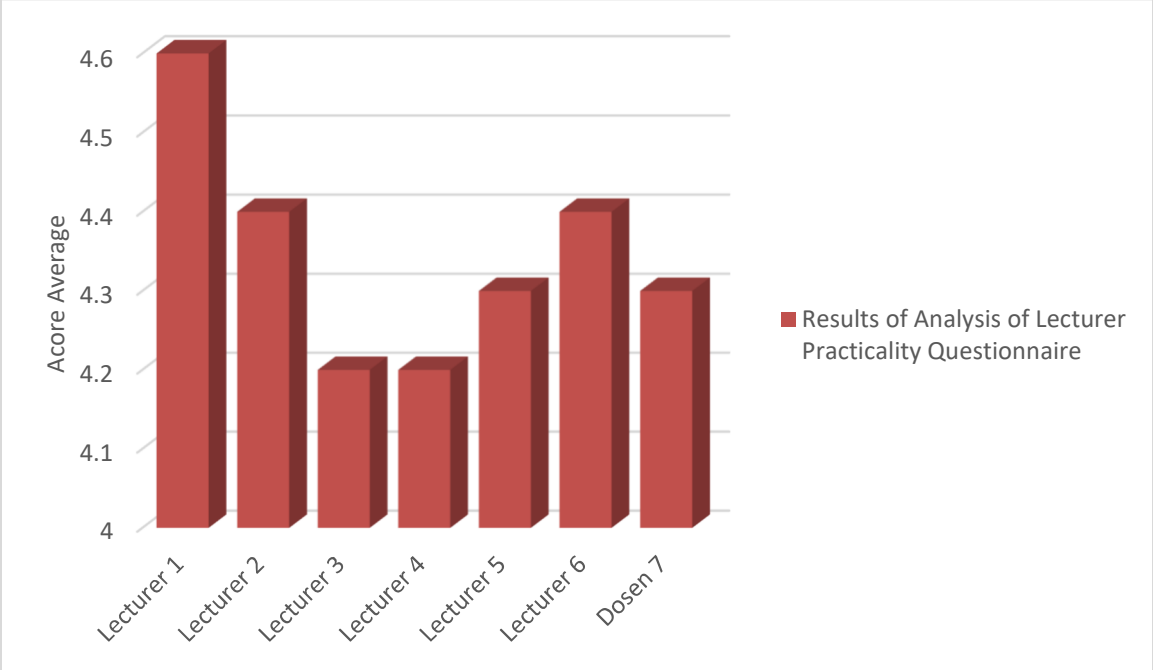

Figure 4. Average Analysis of Lecturer Practicality

The graph demonstrates that, out of the three evaluation criteria that the lecturer evaluated, practicality scored an average of 4.3 and fell into the very good group. This demonstrates that the STEM-PjBL integrated teaching materials created are usable and have a very high practicality rating.

Students' response

After the teaching materials were declared valid and practical, the students were tested by conducting pretests and postests and distributing student response questionnaires. The number of respondents is 92 people consisting of 3 classes, namely classes A, B, and C. Assessment using a response questionnaire with up to 16 statements and a scoring range of 1 to 5, where the assessment factors include the benefits, how the information is presented in the teaching materials, and how the teaching materials themselves seem. Analysis of the questionnaire's responses from the students using the average value of the response questionnaire to determine the level of practicality of the teaching materials developed. The data obtained from the average value of student responses can be seen in the graph as shown in Figure 5.

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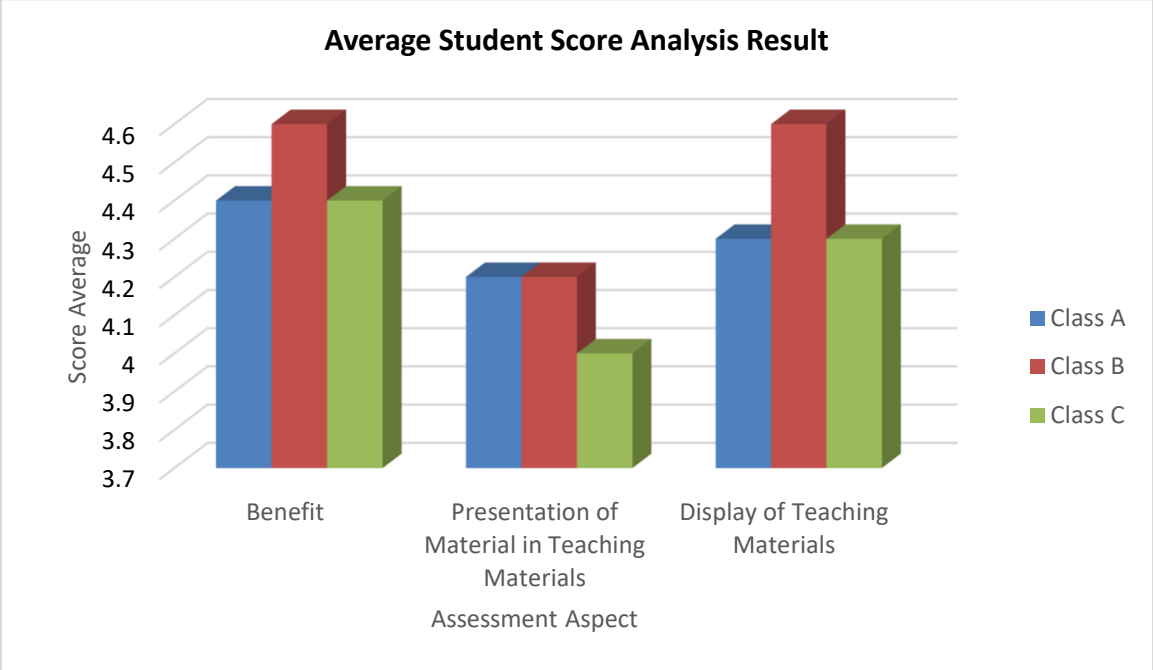

Figure 5. Average Student Score Analysis Results

The figure shows that of the three assessment criteria obtained from student responses to the teaching materials developed, the average value of student responses was 4.3 with a very good category. This shows that the STEM-PjBL integrated teaching materials were developed to provide benefits for students in learning and improve student science literacy.

At the dissemination stage, the STEM-PjBL integrated organic compound teaching materials were distributed in hardcopy and file form. Teaching materials are distributed to students and lecturers who teach general chemistry courses. Teaching materials are also distributed through the SIPDA platform as an LMS used by students in lectures and are also distributed in the form of links using flipbooks.

Discussion

This study seeks to provide products in the form of valid and practical STEM-PjBL integrated teaching resources for organic compound materials. Teaching materials are prepared based on course learning outcomes. By connecting chemistry content with other disciplines and putting it to use with the outcomes of group projects, the teaching materials created are integrated with STEM-PjBL to increase students' science literacy. Research and development is the methodology employed, using Thiagarajan's 4-D development paradigm. The stages of the 4D model consist of 4 stages, namely: (1) Define; (2) Design; (3) Develop; and (4) Disseminate.

At the define stage, an analysis of the problems contained in the lecture process is carried out by conducting a front-end analysis through interviews with lecturers teaching the course, student analysis through interviews with students, task analysis by analyzing course learning outcomes (CPMK), followed by analyzing Sub-CPMK and goal specifications by analyzing learning objectives on organic compound material.

Furthermore, at the design stage, the format and initial design were prepared. In the preparation of the format, the typeface is designed using Times New Roman for the title and content of teaching

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materials, the space between lines is 1.5 with a column format and the paper is adjusted to the UNESCO format, which is 15.5 x 23 cm. The material is arranged systematically and sequentially with a white paper background and a combination of orange and blue contained in the content of teaching materials. According [19], orange gives the impression of being warm and vibrant, while blue is associated with intelligence, communication, trust, efficiency, calmness, duty, and logic. The module's initial layout is organized sequentially and includes a cover, preface, introduction, STEM components, usage instructions, course learning objectives, and concept maps. Then move on to the content section, which includes the material's title and its sub-chapters, each of which begins with a description of the project tasks (PjBL) that students must complete. The content of the material is also associated with other fields (STEM) such as technology, engineering, and mathematics. The closing section consists of a summary, competency test, glossary, bibliography, and author biography.

At the development stage, validation of teaching materials was developed for material experts and media experts as many as 2 people each. The experts conducted an assessment of the teaching materials that had been developed, this aims to see the feasibility of the teaching materials. Using the eligibility formula to analyze the outcomes of expert assessments, 96 from material experts and 91 from media experts are obtained. So, on average, it can be said that the validity evaluation of the created teaching materials had a feasibility value of 93.5 with a very high category (extremely valid). It can be concluded that the STEM-PjBl integrated teaching materials are suitable for use in learning. The teaching materials developed are under the curriculum, the material is accurate, the evaluation is clear, under language rules, able to improve students' science literacy skills, and are under the components of science, technology, engineering, and mathematics.

Furthermore, the practicality test was conducted on 7 lecturers who taught general chemistry courses. This practicality test aims to see how useful the teaching materials developed for lectures are. The results from the seven lecturers who completed the questionnaire were averaged and converted to a practicality value, yielding a very good practicality value of 4.3. This shows that the STEM-PjBl integrated teaching materials developed are practical to use with a very good practicality category.

The instructional materials included information on organic compounds and related fields of science including technology, engineering, and mathematics. The link between the concept of organic compounds and other sciences will increase students' scientific literacy. The teaching materials are also presented various projects related to the material, for example making shoe polish, making aromatherapy candles, making aromatherapy soap, and so on. This project also helps students to be able to understand more complex material and also helps improve students' cooperation skills.

After learning, students were also asked for their responses to the teaching materials used. The results of the questionnaire, which 90 students completed, were then averaged and translated to a practicality rating, with a very good category, giving the average practicality value of 4.3. This shows that the STEM-PjBl integrated teaching materials were developed to provide benefits for students in learning and increase students' interest in learning and science literacy. This is following the research of [20] which shows that STEM-PjBL can increase science literacy, motivation, material understanding, creative thinking skills, meaningful learning effectiveness, and support future careers.

Furthermore, the distribution of STEM-PjBL integrated organic compound teaching materials in the form of hardcopy and file. Teaching materials are distributed to students and lecturers who

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teach general chemistry courses. Teaching materials are also distributed through the SIPDA platform as an LMS used by students in lectures and are also distributed in the form of links using flipbooks.

Conclusion

Based on the results of the research, the conclusions are:

1. The average feasibility value is 93.5 and the category is very high, so the validity test of STEM-PjBL integrated teaching materials on organic compound material is considered very valid.
2. The average practicality score of 4.3 from lecturers and a very good response of 4.3 from students, the practicality test of STEM-PjBL integrated teaching materials on organic compound material was deemed very good.

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Improving students' creative thinking abilities through developing general chemistry teaching materials based on the pjbl stem model

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Abstract. *The ability to think creatively is one of the high-level abilities that every student must have after completing their studies at university. A lecturer is required to be able to develop and design creative and innovative learning that is able to actively involve students and is able to train students' creative thinking abilities. This research aims to develop and produce general chemistry teaching materials on organic compounds and reactions based on the PjBL STEM model in an effort to improve students' creative thinking abilities. The development model used refers to the ADDIE development model. This research and development produces learning products in the form of teaching materials based on the PjBL STEM model and has been declared valid (suitable) for use in learning organic compounds and reactions. Validity is*

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met based on the suitability indicators for teaching materials from the National Education Standards Board (BSNP) which are modified according to university level teaching materials. The results of implementing teaching materials were proven to improve students' creative thinking abilities ($p=0.000 < 0.05$). The results of the research concluded that students' creative thinking abilities can be improved through the development and implementation of general chemistry teaching materials based on the PjBL STEM model.

Keywords: Creative Thinking Ability, PjBL, STEM, Teaching Materials

Introduction

The development of information and technology in the 21st century has had the impact of fundamental changes in various fields, including education. Since the emergence of a global movement calling for new learning models for the 21st century, there has been a growing opinion that formal education must change. The changes in question do not involve changes in curriculum content, but rather changes in pedagogy, namely changes in action from simple action to comprehensive action and a shift from the dominance of traditional teaching to technology-based teaching [1]. Identify student competencies that need to be developed, namely, students must hone their skills and improve their learning to be able to overcome global challenges, such as creative thinking skills, the ability to communicate effectively, innovate and solve problems through negotiation and collaboration [2].

Creative thinking skills are one of the most important goals at all levels of education, which are related to the ability to identify, analyze and solve problems creatively and logically so as to produce the right considerations and decisions [3]. The ability to think creatively is very important for students because by having creative thinking skills students are able to be rational in choosing various alternative choices that are best for themselves. The creative thinking abilities possessed by each individual are certainly different, depending on the exercises that are often carried out to develop them [4].

Creative thinking can be defined as a person's attempt to check the truth of information using evidence, logic and awareness of bias [5]. Creative thinking is a potential that every person has, it can be measured, trained and developed. People who think creatively ideally have several basic criteria or elements which are abbreviated as FRISCO (Focus, Reason, Inference, Situation, Clarity, and Overview) [6].

Lecturers as educators are also required to be able to design learning that is oriented towards active student involvement and is expected to stimulate students to be able to think creatively and be able to solve the problems they face [4]. Strategies to improve creative thinking skills are very urgent for students because they are related to life skills competencies for students after completing their studies at university. Creative thinking skills are very important for a student to have which can be used as a basis for solving problems at any time. This includes scientific activities such as asking questions, making statements, making the right choices, and drawing decisions in chemical experiments [7].

The principles of learning in the 21st century use a student-centered learning approach, where the teacher/lecturer acts as a facilitator. 21st century learning emphasizes students' ability to formulate problems, find out from various sources, think analytically, creatively, creatively and collaborate and collaborate to solve problems [8]. One alternative that can be applied to improve students' creative thinking skills, including in chemistry learning, is project based learning (PjBL).

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PjBL is an ideal model to complement educational goals in the 21st century because it involves the 4C principles, namely creative thinking, communication, collaboration and creativity [9].

PjBL has great potential to provide a more interesting and meaningful learning experience for students, so that PjBL becomes a learning model that supports the 2013 curriculum [10]. In PjBL, students determine their own learning process collaboratively, conduct research and create creative projects that reflect the knowledge they have. This can be done through introducing various knowledge and skills using technology and then honing students' communication and problem solving skills [11]. Several studies also show that the implementation of PjBL is effectively applied in learning [12], able to increase student activity and learning achievement [13], improve creative thinking skills [14], increase ability communication [15], improving creative and creative thinking skills [16] [17]; improving collaboration skills and learning outcomes [18]; improving literacy skills [19]; and is able to increase students' HOTS [9] [20] [21].

Creative thinking skills are one of the skills that every student must have in order to successfully face challenges, problems, life and careers in the 21st century. The very rapid development of science and technology also requires educators to prepare students who are able to think creatively and are competent in various fields. The competent fields needed to deal with these various things are Science, Technology, Engineering, Mathematics (STEM). STEM includes processes of creative thinking, analysis and collaboration in which students integrate processes and concepts in real-world contexts of scientific skills and competencies for college, career and life [22].

The STEM approach is an integration of science, technology, engineering, and mathematics learning that is recommended to foster success in 21st century skills. Learning that integrates STEM has a big influence on academic achievement. STEM can develop if it is connected to the environment, so that learning can be realized that presents the real world that students experience in everyday life. This means that through the STEM approach, students do not just memorize concepts, but rather how students understand and comprehend scientific concepts and their relationships in everyday life [23]. Several studies also show that the STEM approach can improve students' creative thinking abilities [24] [25] [26] [27]; improve creative thinking skills [28]; as well as being able to improve student learning outcomes [29] [30].

Method

This research is a type of development research or research and development (R&D), namely a type of research that produces products rather than testing a theory, which is a process used to develop and validate educational products and test the effectiveness of these products [31]. The result of this development research is a PjBL model with a STEM approach to learning organic compounds and reactions.

The development model used refers to the ADDIE development model. The research subjects were 36 students. Data collection techniques and methods in this research include: interviews; validation sheet (check list); and creative thinking ability tests. The creative thinking ability test instrument was developed and prepared according to the competency achievements in learning organic compounds and reactions in the form of a description/essay test.

Research data is analyzed in stages to determine the feasibility (validity) and effectiveness of the educational products being developed. Data from expert validation results are analyzed by considering input, comments and suggestions from validators based on the validation sheet. The

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results of this analysis are used as guidelines for revising teaching materials using the PjBL STEM model that was developed.

The effectiveness of products in the form of teaching materials using the PjBL STEM model developed was obtained from the results of creative thinking ability tests carried out by students. The increase in students' creative thinking abilities was tested using the t-test or paired sample t-test approach with the help of the SPSS program.

Result and discussion

The product developed in this research and development is in the form of General Chemistry teaching materials based on the PjBL STEM model in learning organic compounds and reactions which is intended to improve students' creative thinking abilities. Validation of teaching materials is assessed by expert validators in their fields. General Chemistry teaching materials based on the PjBL STEM model in learning organic compounds and reactions produced, and have been declared valid (feasible) will then be implemented for students to analyze the increase in students' creative thinking abilities.

Validity of Teaching Materials

Validity (feasibility) of General Chemistry teaching materials based on the PjBL STEM model for learning organic compounds and reactions developed, evaluated and assessed by expert validators based on the suitability of the material and the suitability of the media.

Table 1. Results of validation of teaching materials

Assessment Aspects	Validator (average score)			Total Average	Criteria
	I	II	III		
Content materials	4.50	4.63	4.88	4.67	Valid
Presentation of materials	4.50	4.50	4.63	4.54	Valid
Language	4.50	4.67	4.50	4.56	Valid
Use of learning models	4.60	4.80	4.80	4.73	Valid
Evaluation and assessment	4.67	4.83	4.67	4.72	Valid
Graphics	4.83	4.67	4.92	4.81	Valid
Average validation results				4.67	Valid

Table 1, shows the results of the assessment by expert validators and obtained an average total score of 4.67 or declared to have met the valid (eligible) criteria. Thus, it is concluded that General Chemistry teaching materials based on the PjBL STEM model are classified as valid and suitable for application in the learning process of organic compounds and reactions.

Achievement of Students' Creative Thinking Abilities

Achievements of students' creative thinking abilities were obtained through tests given to students before (pretest) and after (posttest) learning actions were given by implementing General Chemistry teaching materials based on the resulting PjBL STEM model. Implementation of teaching materials was carried out for 36 students.

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Table 2. Results of student critical thinking ability achievements

	N	Min	Max	Mean	Std. Deviation	Kolmogorov-Smirnov test	
						Statistic	Sig.
Pretest	36	35	55	46.72	4.470	0.842	0.478
Posttest	36	75	98	88.59	5.036	0.838	0.484

Table 2 shows the pretest results of students' creative thinking abilities before being given action and obtained a pretest average of 46.72±4.470 and the data has a normal distribution with a Kolmogorov-Smirnov test value of 0.842 (p=0.478>0.05). After being given action using General Chemistry teaching materials based on the PjBL STEM model, the post-test results showed that the average post-test score for students' creative thinking ability was 88.59±5.036 and the data had a normal distribution with a Kolmogorov-Smirnov test value of 0.838 (p=0.484>0.05).

Increasing Students' Creative Thinking Abilities

The increase in students' creative thinking abilities can be seen based on the results of implementing teaching materials based on the PjBL STEM model in the learning process. The increase in students' creative thinking abilities was analyzed statistically using a paired sample-test approach with the help of the SPSS program.

Table 3. Test the significance of increasing students' creative thinking skills

	Paired Differences		t	Sig.
	Mean	Std. Deviation		
Posttest-Pretest	41.972	8.341	30.193	0.000

Table 3 shows the results of the analysis of increasing students' creative thinking abilities with the difference between the average post-test and pre-test scores of 41.972±8.341 and the results of statistical hypothesis testing obtained a t-count value of 30.193 with a probability (sig.) of 0.000 < 0.05. Thus, it is concluded that the implementation of General Chemistry teaching materials based on the PjBL STEM model has been significantly proven to be effective in improving students' creative thinking abilities in learning organic compounds and reactions.

Discussion

The educational product developed in this research and development is in the form of General Chemistry teaching materials based on the PjBL STEM model with the aim of improving students' creative thinking abilities in learning organic compounds and reactions. The teaching material product was developed by referring to the ADDIE development model. The results of the expert validator's assessment of the General Chemistry teaching materials based on the PjBL STEM model developed have been declared valid and suitable for implementation in the learning process. The validity of teaching materials is fulfilled qualitatively based on the assessment of expert validators according to the assessment aspects of the National Education Standards Agency (BNSP) including the appropriateness of material content, material presentation, language, use of learning models, evaluation and assessment as well as modified graphics in accordance with teaching materials at university level.

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At the implementation stage, the use of General Chemistry teaching materials based on the PjBL STEM model in the learning process of organic compounds and reactions was also proven to be effective in improving students' creative thinking abilities. The increase in students' creative thinking abilities was met quantitatively based on pre-test data before being given actions and post-test data after being given learning actions as well as statistical test results ($p=0.000<0.05$). Student responses to the General Chemistry teaching materials based on the PjBL STEM model produced were also very positive.

The findings of this research and development also have implications for lecturers that improving the achievement of learning outcomes, especially students' creative thinking abilities, can be done by designing and developing innovative learning, one of which is by developing teaching materials based on the PjBL STEM model. Through teaching materials based on the PjBL STEM model, it can help students improve their understanding, mastery and train and improve students' creative thinking abilities.

Conclusion

This research and development produces educational products in the form of General Chemistry teaching materials based on the PjBL STEM model on Organic Compounds and Reactions. Teaching materials were developed referring to the ADDIE development model and have been declared valid (feasible) to be applied to the study of organic compounds and reactions, both in terms of appropriateness of material content, material presentation, language, use of learning models, evaluation and assessment as well as appropriateness of graphics according to BSNP with modifications according to teaching materials at university level. Implementation of General Chemistry teaching materials based on the PjBL STEM model in learning organic compounds and reactions has also proven to be effective in improving students' creative thinking abilities with an average increase or difference in students' creative thinking ability scores (post-pretest) of 41.972 ± 8.341 and proven by test results. statistical hypothesis with a probability value (p) = 0.000 < 0.05.

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Evaluation of Academic Collaboration Activities Supporting the Achievement of University Performance Indicators

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Abstract. *Collaborative activities carried out by universities in the academic and non-academic fields are one of the parameters for achieving key performance indicators. Collaborative activities that have been initiated by university members have been coordinated by the university to facilitate mutual collaborative activities. The problem is that the collaborative activities carried out by universities have not been focused on the achievement of university key indicators. This research aims to evaluate the*

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implementation of academic collaboration carried out by universities to support the achievement of university performance indicators. The research was carried out by collecting data on the availability of cooperation policies, analyzing the suitability of cooperation governance instruments, recording university cooperation activities, and recommending improvements of the university performance indicators. Evaluation is carried out on academic activities that support improving university performance and implementing cooperation in achieving the University's goals, objectives, and strategic plans. The research results show that policy documents, governance tools, and implementation in the field of cooperation to achieve the university's main performance indicators have been recorded. The documents have been proven to be effectively to facilitating cooperation activities for the achievement of key performance indicators. The achievement of university performance is a reflection of the suitability of academic collaboration within the university environment and is also used to improve performance achievements in subsequent areas of collaboration. Cooperation governance policies and instruments greatly determine the success of the university's main performance achievements. The results of this research have recommended collaborative activities to improve the university's main performance indicators.

Keywords: University Collaboration, Key Performance Indicators, Collaboration Governance, Academic Activities.

Introduction

Evaluation of institutional performance aims to present a conceptual framework of achievements that can be used to demonstrate the quality of institutional performance based on the achievement of targets that have been set [1,2]. Performance evaluation is used as a means of communicating achievements and their balance against the strategic plan that has been established [3]. The policy of the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia has determined eight main performance indicators to be achieved by universities through a Ministerial Decree [4]. Performance evaluation is very important for decision-makers in improving service quality, quality improvement, policy making, and management [5]. Various strategies are used in measuring performance in higher education. One good strategy is through measuring collaboration performance, namely based on collaboration achievements to increase productivity in the fields of research, publications, and other outputs [6]. Total quality management and internationalization are used as models for evaluating higher education performance [7-9].

Achieving performance cannot be separated from the role of collaboration, and the availability of standard collaboration governance tools is a guideline used by the community and collaboration partners [10]. Collaboration with mutually beneficial partners is really needed by universities, especially to facilitate students in academic and non-academic programs, all of which will provide benefits to the partnering units [11-13]. Evaluation of the implementation of university collaboration activities is a reflection of the implementation of academic and non-academic activities at the university which synergize in achieving the university's main performance. This research aims to evaluate the implementation of academic collaboration carried out by universities to support the achievement of Key Performance Indicators (KPI) as a means of seeing the extent to which planned activities have been achieved to improve quality at the University.

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Research Method

Location and Research Object

The research was conducted at Universitas Negeri Medan involving collaboration partners in Indonesia. The object of the research is related to collaboration (documents and collaborative activities) carried out by Department and Study Program functionaries within the University environment with collaboration partners, to support the achievement of university performance indicators.

Population and Sample

The research population is academics and university collaboration partners. The research samples were students, functionaries, lecturers and collaboration partners involved in university collaboration activities.

Research Procedure

Evaluation of the implementation of activities in the field of University collaboration was carried out following the procedures described in previous research with modifications [11-13], including: (1) Collecting data on policy documents, governance instruments and activities in the field of cooperation, and implementation operational standards in the field of cooperation, (2) Analyzing data on the results of activities in the field of cooperation and connecting them with performance indicators and achievements of the university's Strategic Plan, (3) Sorting and formulating The collected research results and processing results will be in a discussion group forum to obtain complete information about academic and non-academic activities related to the field of cooperation that facilitate the achievement of KPI and the university's Strategic Plan, and (4) Providing recommendations for follow-up in the field of cooperation university.

Results

University Collaboration Policy and Governance

The implementation of university collaboration programs is facilitated and guided by university policy documents, governance instruments, operational standards for implementing collaboration, and activities in the field of collaboration. Various programs and activities in the field of cooperation have been carried out including national cooperation within the country and international cooperation. The policy documents that regulate university activities are summarized in Table 1. The policy documents and governance instruments detail the procedures and steps that must be taken in implementing collaboration. Guided by these formal documents, all university members will carry out collaborative activities correctly, appropriately and in accordance with the regulations set by the university. The list of operational standards for implementing cooperation is summarized in Table 2.

Table 1. Collaboration policy documents supporting the achievement of key performance indicators and University goals.

No	The Documents	Descriptions
1	University Collaboration Handbook	Providing guidelines for managing collaboration between universities and stakeholders (collaboration partners), as written rules issued by the Chancellor, regarding the governance of University collaboration, including planning, implementation, evaluation and follow-up on collaboration in the academic and non-academic fields.

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2	National cooperation governance	Arrange guidelines for implementing collaboration to complement the Chancellor's regulations, including activity planning, funding, implementation and reporting of University collaboration activities, which are carried out with partners in the country
3	Governance of international cooperation	Regulate the management of international cooperation related to student activities, lecturers and university residents carrying out international cooperation activities, including planning, funding (cost sharing), licensing, implementation, reporting and follow-up to University cooperation activities carried out with international partners.

Table 2. List of operational standards for implementing collaboration that supports the achievement of the university's main performance indicators.

No	Title of operational standards	Description of the Documents
1	Operational standards Initiating University Collaboration	The steps that must be taken by university members in initiating collaboration include identifying and exploring the potential for university collaboration with collaboration partners.
2	Operational standards for issuing a memorandum of understanding (MoU)	Procedures that must be carried out in issuing a Memorandum of Understanding (MoU), as a legal and binding agreement for the University and cooperation partners, as well as a statement of agreement between the two partnering parties as stated in the contents of the agreement.
3	Operational standards for issuing letters of activity (LoA)	Procedures that must be carried out in issuing a cooperation activity agreement (LoA), regulate the technical implementation of the agreement (as a contract) which binds the parties, and explain who (position) signs the statement of agreement
4	Operational standards for implementing collaborative activities	Standard procedures that must be carried out in the technical implementation of cooperation activities, including regulating (resource sharing) the use of resources and funds, reporting cooperation activities, product ownership rights, and evaluating the implementation of cooperation for sustainability.
5	Operational standards for monitoring and evaluating collaborative activities	Standard procedures that must be carried out in carrying out, monitoring and evaluating collaborative activities as a guarantee of the quality of collaboration implementation, and providing input for follow-up on monitoring results for improvements in the implementation of the next collaboration.
6	Operational standards in implementing the University's MBKM	Standard procedures that must be carried out in collaboration activities to support the Independent Campus Learning (*Merdeka Belajar Kampus Merdeka]* (MBKM) program.
7	Operational standards for Domestic and International University Cooperation	Standard procedures that must be carried out in domestic and foreign cooperation carried out by the University, including the Office of International Affairs.

University Collaboration Partners

University collaboration with collaboration partners has been carried out well, guided by the governance tools available at the university. Institutional collaboration begins with the signing of a memorandum of understanding on collaboration between university leaders and collaboration partners. This document is then used as a basis for designing and implementing activities in units within the university. Collaboration activities are always prioritized to support the achievement of university performance indicators, and the types of collaboration activities that have been implemented are summarized in Table 3. The main principle in implementing collaboration

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activities is equality and mutual benefit between the university and partners. The agreed memorandum of understanding is then followed up into collaborative activities to meet the needs of both partnering parties as agreed in the cooperation agreement document. All collaborative activities between the University and cooperation partners have been focused on supporting the achievement of the university's main performance.

Table 3. Recapitulation of Memorandum of Understanding Documents on University Collaboration carried out with various agencies that support the achievement of the university's main performance indicators.

No	Partners Institution	Year					Total
		2019	2020	2021	2022	2023*	
1	State and regional owned enterprises (BUMN/BUMD)	17	25	39	91	14	186
2	Domestic State Universities	11	40	27	13	22	123
3	Domestic Private Universities	6	8	22	18	20	74
4	Foreign Universities	8	6	27	10	13	64
5	Business Entities and Private Agencies	1	4	4	1	15	25
6	Foreign Institutions	0	9	1	1	4	15
7	Other Institutions	4	3	8	7	17	39
	Total	47	95	128	141	115	526

*Data until July 2023

Implementation of the University Collaboration Program

Several collaborative activities, covering academic and non-academic fields, have been carried out by the University's academic community to support the achievement of the university's main performance. The cooperation agreement that has been agreed upon, in its implementation, is always guarded and monitored so that it focuses on solving the problems required by the cooperation partners. The university has used the resources available at the university to ensure the achievement of its goals. Constructive suggestions are always sought from collaboration partners to improve services to ensure collaboration activities are carried out optimally. Collaborative activities in the academic and non-academic fields have been carried out well and all support the achievement of university performance indicators and the achievement of the university's strategic plan. The scope of cooperation activities is summarized in Table 4.

Table 4. Scope of collaborative activities carried out by the University with collaboration partners to support the achievement of the university's main performance indicators.

No	Scope of collaborative activities
1	Collaboration at the Study Program level in the academic field includes lectures, teaching, training, internships, student and lecturer activities, evaluation and standardization, and joint seminars
2	Academic improvement through future studies (Training, Professional Education, Masters and Doctoral degrees) to meet the needs of special personnel in district and city governments, make government programs, MBKM and other programs a success according to university excellence
3	Teacher education and training in the areas of pedagogical competence (approaches, methods, models, learning media, or learning strategies), and professional competence (mastery of subject matter according to the field of study)
4	Development of human resources in the field of research and community service such as (Educational Character and Administration, classroom action research, development research, policy research), development of School Principals, Supervisors and Teachers, development of employees in the field of innovation, programming, publication of scientific papers, management schools, laboratory management,

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	and competency training for specific purposes, according to the needs of city and district governments, and private agencies.
5	Mapping human resources and competencies, mentoring superior schools, coaching bilingual schools, mentoring and coaching teachers and students at national and international Olympiads, mapping student talents, mentoring and counseling, guaranteeing school academic quality, standardization, evaluation and selection, etc.
6	Community empowerment in the field of Economics and Cooperatives includes: Guidance and assistance for economic actors, Development of Small and Medium Enterprises, Development of Cooperatives, etc.
7	Assistance in preparing regional development plans, planning activity funds, planning regional government programs, as well as implementing and reporting government programs.
8	Development in the tourism sector includes: development of accompanying tourism and tourist resources, improvement and creation of regional souvenir designs, handicraft packaging designs, special mascot and symbol designs according to district and city needs, etc.
9	Collaborative research and development in various fields of knowledge and expertise with domestic and foreign higher education partners (including QS-100), local governments, and business entities, etc.
10	Coaching, mentoring and training in the fields of culinary, tourism, Micro, Small and Medium Enterprises (MSMEs), make-up and clothing according to the needs of local governments and business units, etc.
11	Coaching, mentoring and improving the sports sector includes: selection, coaching regional athletes, and mentoring skills, etc.
12	Guidance, assistance and improvement in the fields of science, engineering, education, social science, culture and language that support improved services in district and city governments.

Table 5. Description of cooperation partners' satisfaction with the implementation of the agreed cooperation

No	Collaboration activity indicators	Respondents' Opinions (M±Sdv, n=54)
1	Problem-solving strategies and innovation in university collaboration services	8.24±0.65
2	Suitability of expertise, resources and funding with the type of collaboration services expected by partners	8.07±0.68
3	Benefits of collaborative activities in solving partner problems	8.08±0.70
4	Collaborative accountability, openness, commitment and responsibility of the university for the agreements that have been made	7.97±0.79
5	The desire to carry out further collaborative activities	8.11±0.82
	Average	8.09±0.73

*Assessment criteria: (1-3) Strongly disagree-disagree, (4-6) Neutral-disagree, and (7-9) Agree - Strongly Agree

Evaluation of Collaboration Partner Satisfaction

Evaluation of cooperation partners' satisfaction with the implementation of cooperation has been carried out. The scope of evaluation is based on the opinions of cooperation partners regarding services, achievements and suitability of cooperation implementation with agreed agreements. The evaluation results provide an overview of accountability in implementing collaboration. Evaluations are carried out periodically using surveys, and a summary of respondents' opinions is shown in Table 5. Respondents gave a very good assessment of all components of cooperation activities, an average of 8.09±0.73 (see data in Table 5).

Discussion

University collaboration programs with partners have been facilitated through the provision of policy documents and governance instruments that regulate the implementation of collaboration. Various higher education collaborations have been established through memorandums of understanding (MoU) and implemented in the form of Memorandum of Agreement (MoA) or Letter of Agreement (LoA) to meet the needs of collaboration partners [11-13]. The principles of

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equality and mutual benefit are always maintained through cooperative activities as a means of demonstrating the university's excellence in solving problems faced by cooperation partners [14]. University collaboration activities are carried out following collaboration guidelines at all stages starting from planning, preparation, implementation, monitoring, to reporting. Evaluation of the stages of collaboration is carried out to see the strengths and weaknesses of collaboration as recommendations for follow-up actions in subsequent collaboration activities. The cooperation program has been carried out optimally involving the active participation of all parties [15]. Units at the university seek to leverage the university's expertise and resources to solve problems faced by collaborative partners. Collaborative activities have had an impact on achieving the university's main performance indicators. These activities include providing scholarships, strengthening cooperation through student credit transfers with domestic and foreign universities, collaboration with government agencies/industry/institutions, and collaboration with overseas partner institutions, higher education clustering policies, local cultural orientation for foreign students, activities academics with foreign universities, strengthening the management of global indexed journals, strengthening the implementation of independent learning on independent campuses, and lecturer activities with universities in the World Class University category [16,17]. Partners provide very good assessments of the university's collaborative activity services. Effective implementation of cooperation helps partners, and cooperation partners are committed to continuing future cooperation activities according to stakeholder needs. The sustainability of this collaboration is proof that the collaboration carried out with Collaboration partners has provided good results.

Conclusion

Evaluation of the implementation of university collaboration activities has been carried out to obtain information and data about collaboration that supports the achievement of the university's main performance indicators. The implementation of cooperation is guided by policy documents, governance tools and cooperation activities. Various types of collaborative activities have been carried out well with a focus on achieving the university's main performance indicators. From the evaluation results, complete information and data regarding policies, governance instruments and operational standards for implementation in the areas of planning and cooperation activities have been obtained. Policy documents have been used to facilitate collaborative activities in academic and non-academic fields. The collaborative activities carried out aim to improve the quality of services at the university and achieve performance by utilizing the university's advantages to achieve the university's vision, mission and goals in accordance with the strategic plan set by the university. The results of this research provide recommendations for improving the performance of the cooperation sector at the next stage.

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The effect of web media on increasing student learning outcomes in material analysis instruments

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Abstract. This study aims to find out whether the use of Web-based media used can increase student competence in lectures on the topic of Instrument Analysis?, are learning outcomes using Webb media better than without using Webb media?, and to determine student responses to the use of Webb-based media in lectures Evaluation of the topic of instrument analysis. The population in this research was students majoring in chemistry education who were taking the Evaluation course as many as 4 classes and 2 classes were purposively taken as samples of the experimental and control classes, each of which consisted of 26 students. The method used in this study is a quasi-experimental method with a quantitative approach. The research design used was *Pre-Test* and *Post-Test* Control with one kind of treatment. Data analysis techniques used Gain Test, one-party t test and descriptive analysis of student responses by calculating percentages. The results showed that the experimental class gain taught using Web media was 0.75, while the cock class gain without Web media was 0.56. The t test shows $t_{count} = 2.75 > t_{table} = 1.684$, namely the learning outcomes of students who are taught using Webb media are higher than the learning outcomes of students who are taught without using Webb media. While student responses to the use of Web-based media used are in the very high category. Thus, it can be concluded that the use of Web media is very good in lectures. Evaluation of instrument analysis topics.

Keywords: Web-Based Media, Improvement, Learning Outcomes

Introduction

Instrument Analysis is one of the important topics in Evaluation courses, which students of the education study program must learn, especially prospective teachers. Instrument Analysis Material consists of Test and Non-test instruments which require students to be able to make, test and analyze the instruments they have made. This has a lot to do with formulas and

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requires special calculations to analyze it. Based on the results of observations in class during the teaching and learning process of Evaluation lectures, students experienced difficulties when doing assignments on instrument analysis material which had an impact on their learning outcomes. The low final semester exam scores lie in the difficulty of students working on problems related to Instrument Analysis material. Students' difficulties in studying Instrumental Analysis materials, which so far have only used Evaluation textbooks, should be assisted with the use of media[6]. The use of media is very necessary in learning. One of the media that is very popular today is the use of the internet in the world of education, especially in making web-based learning media [1]. The government has made various facilities such as technology training by educators and internet connections in schools, but some educators who are not interested in technology are still not using it [2]. So, there is a need for further guidance on learning media and follow-up to immediately connect internet technology in various regions so that the use of learning media using the internet is more communicative [3].

Through the internet, accessing information is very easy to do anytime and anywhere, but there are a number of things that need to be considered, namely the information obtained is often unstructured. Result in learning activities that are not optimal. With the existence of Web-based learning media, it is hoped that students will get the maximum learning experience through a structured learning process that can be accessed anytime and anywhere and can also be controlled if necessary. Using Webb via smartphones can make students more interactive and involve students in learning. The web is a system that can communicate easily by utilizing internet facilities so that communication activities can be carried out without being limited by distance, place and time [4].

A website usually consists of many interconnected web pages[5] while VD[14] say that the Web facilitates a student-centered approach, creating a motivating, active and flexible learning environment. The web can be used as learning, to make it easier for students to understand concepts or learning materials.

This research aims to find out whether the use of Web-based media can improve student competence in lectures on the topic of Instrument Analysis? Are learning outcomes using Webb media better than without using Webb media?, and to find out students' responses to the use of Webb-based media in lectures.

Methodology

This research was conducted at the Unimed chemistry education department with a population of students who were taking 4 class evaluation courses and 2 classes taken as purposive samples.

The variable in this research is Webb-based media in Instrument Analysis material as an independent variable, while the dependent variable is student learning outcomes in that material.

The research design used to measure the level of student learning ability is a pretest-posttest control group design. In this design, two sample groups are used purposively from the population. Where the first group sample is experimental class 1 which is taught using web media and the second group sample is the control class which is taught without using Webb media.

The method used in this research is a quasi-experimental method with a quantitative approach. The research design used is the Pre-Test and Post-Test Control with one type of treatment. [1] describes the research method as follows:

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Table 1. Research design

Group	Pretest	Treatment	Postest
Experiment	T1	T2	Q2
Control	T1	-	Q2

Data Collection Techniques and Data Analysis

The data used is in the form of pretest and posttest for the experimental class and control class, while the data analysis technique used is:

1. To find out how much the use of Webb-based media can improve students' abilities in lectures on the topic of Instrument Analysis, the Normalized Gain Test (N-Gain) is used with the following formula:

$$g = \frac{skor\ posttest - skor\ pretest}{skor\ maksimum - pretest}$$

As for the Gain category, the increase in student abilities can be seen in table 2.

Table 2. Gain test category

Interval	Category
g < 0,3	Low
0,3 ≤ g ≤ 0,7	Currently
g > 0,70	High

1. To see whether the learning outcomes using Webb media are better than without using Webb media, after the Data in the research is proven to be normally distributed and the variance is homogeneous, then the T-test analysis technique, right side, is carried out[8]. The t-test is used to test differences in student learning outcomes between classes taught using Webb media and classes taught without using Webb media.
2. To find out student responses to the use of Webb-based media in lectures, questionnaires were used and analyzed descriptively. The formula used is:

   P = $\frac{f}{n}x$ 100%

   Information:

   P = Percentage of student responses

   F = The percentage being searched for is the frequency

   N = The total number of objects

Table 3. Criteria for Student Responses to Web-based media

Score	Percentage Interval	Criteria
16 – 20	83% s/d 100 %	Very high
13 – 16	67 % s/d 83%	High
10 – 13	51 % s/d 67 %	Currently
7 – 10	35 % s/d 51 %	Low
4 – 7	20 % s/d 35 %	Very low

The results of the data analysis are then adjusted to the agreement figures so that validity criteria and figures can be determined and conclusions can be drawn from the results of the analysis.

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Result and discussion

Student Learning Outcome Data

Before being given treatment in each experimental class, a pretest was given to measure students' initial abilities using instruments that had been declared valid. In summary, the results of the pretest and posttest of students in the experimental class and control class can be seen in Tables 4 and 5 below:

Table 4. Mean Value of Learning Outcomes for Experimental Class Students

Average value	N	Min	Max	Mean	Standard Deviation
Pretest	26	20	50	43,00	6,513
Posttest	26	70	95	82,17	6,524

Table 5. Mean Value of Control Class Student Learning Outcomes

Average value	N	Min	Max	Mean	Standard Deviation
Pretest	26	20	45	37,50	5,37
Posttest	26	65	72	65,83	8,31

From Table 4 and Table 5 it can be seen that the average pretest score in the experimental class was 43 and the posttest average score in the experimental class was 85.17. Meanwhile, in the control class, the pre-test average was 37.65 and the control class was 65.83. Thus, it can be concluded that the average scores of students who are taught using Webb-based media are different from those taught without using Webb-based media.

The results of the Gain calculation for the experimental class and the control class are shown in table 6.

Table 6. Experimental Gain Test and Control Class

Class	Average of Gain	Percentage of Gain	Classification
Experiment	0.75	75%	High
Control	0.56	56%	Medium

Table 6 shows that the average normalized gain value for the experimental class is 0.75 in the high category. Meanwhile, the N-Gain value in the control class is 0.56 in the medium category. So it can be concluded that there is a difference in the increase in student learning outcomes taught using Webb-based media and the increase in student learning outcomes taught without using Webb-based media. That the application of e-learning based weblogs as a learning resource is effectively used in learning and increases learning outcomes by 71.30%[9]. Meanwhile, that web-based learning can improve the knowledge and communication skills of college students.

Hypothesis Testing

To find out whether Ho is accepted or rejected, a hypothesis test is carried out However, the normality test is first performed homogeneity, and the results of data analysis show that the data is normally distributed and homogeneous. The results of the Hypothesis Test can be seen in the following table:

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Table 7. Hypothesis Test (right-sided t-test)

Data	Mean	Standard Deviation	N	t_{count}	t_{table}	Information
Class posttest Experiment	82,17	6,52	26	2.75	1,69	Ha accepted
Control Class Posttest	65,83	8,31	26			

Based on the data analysis carried out, the results of the hypothesis test were obtained, namely right-sided t test, obtained $t_{count} > t_{table}$, with $t_{count} = 2.75 > t_{table} = 1.684$, this means the alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected. This matter shows if the learning outcomes of students who are taught using Webb media are higher than the learning outcomes of students who are taught without using Webb media. The results research that learning outcomes using weblogs were higher and there was an increase in learning outcomes of 56.2% in using Web media[10]. This relates that by using the web all information related to the learning material being taught can be uploaded so that the material is more interesting and easier to learn[7]. The web is one of the media using technology shows that learning to use digital media or technology is more meaningful in terms of students' metacognition than non-digital[11]. Meanwhile, web-based learning offers great opportunities for learning and access to large amounts of knowledge and information[12].

Student Response Data

Data on student responses to the use of web-based learning media collected using a questionnaire. Of the 26 student respondents who were studying the topic of Instrument Analysis, the results obtained from the analysis were that 100% of students enjoyed learning instrument analysis material, 88.5% of students said they learned using Web media is nothing new, 90% of students stated that the text and images displayed on the Web are clear and easy to understand, 100% of students stated that learning using the web was interesting and interesting fun, 90% of students stated that the images displayed helped students' understanding. Research also found a positive response of 90% to the use of Web media in learning[13].

Conclusion

This study concludes that the use of Web-based media can increase student competence in lectures on the topic of Instrument Analysis, namely 75% for experimental classes that use Web media and 56% for classes without Web media. Learning outcomes in using Webb media are better than without using Webb media and student responses to using Webb-based media in lectures Evaluation of the topic analysis of the instrument is very high. Thus, it can be said that the use of Web media is very good in lectures. Evaluation of the topic of instrument analysis.

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Implementing of prior knowledge evaluation and 5E learning cycle in stoichiometry learning design to improve students' critical thinking skills

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Abstract. *The goal of this study is to create a stoichiometry learning tool for the general chemistry course that may increase critical thinking abilities by analyzing students' prior knowledge and the 5E learning cycle (Engagement, Exploration, Explanation, Elaboration, and Evaluation). Stoichiometry learning materials include: 1) the semester learning plan; 2) the prior knowledge evaluation; 3) the teaching materials; 4) the students' activity sheets; and 5) the evaluation of learning outcomes developed using a three-stage process framework, which includes: a) needs analysis, b) production and implementation of learning designs, and c) evaluation of the outcomes of implementing learning designs. The time required to implement the stoichiometry learning design at each meeting, which includes: a) carrying out the prior knowledge evaluation and discussing it for 10-15 minutes, b) delivering the teaching materials for 60 minutes, c) filling out the student activity sheets and observing it for 15-20 minutes, and d) carrying out the evaluation of learning outcomes for 10 minutes. The results of observations of stoichiometry learning in a small class of 37 students divided into two meetings revealed that as many as 41% and 57% of students were able to complete the students' activity sheets using a gradual problem solving method in the excellent category. Students who are declared able to ask questions or opinions about the concept being studied and then connect and develop it with other concepts related to the excellent category receive 24% each, while students who are able to explore personal experiences and build group experiences when working together in teams complete the student activity sheets with the excellent category are 24% and 14%. Even though student involvement in constructing new knowledge during learning is in the poor category, it is believed that if implemented continuously, this learning design can create a learning culture and critical thinking skills in students. The IBM SPSS Statistics 22 programme is used to process the multiple regression equation for the effect of the independent variables (the prior knowledge evaluation and students' activity sheets) on the dependent variable (the evaluation of learning outcomes), and the results show the linear regression line and significant regression equation coefficient while there is no multicollinearity among the independent variables, with a coefficient of determination (R^2) = 44.9%. If implemented consistently, this learning media design can be a learning strategy that nurtures the students' learning culture and critical thinking skills.*

Keyword : chemistry neducation, stoichiometry, critical thinking skill, learning media

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Introduction

Stoichiometry is a chemical calculation that uses the basic legal concepts of chemistry and the mole concept to determine the reactants that react and the products that result from an ionic reaction equation or a molecular reaction equation. Stoichiometry is one of the learning materials in the general chemistry course that students feel challenging, despite the fact that this learning material was previously covered when taking chemistry lessons at the Senior High School level.

Students need to be proficient in both verbalistic and numerical reasoning in order to apply the basic concepts of chemistry and the mole concept to the solution of a stoichiometry-related problem. Students' engagement in creating new information throughout learning, both individually and in groups, will be influenced by their proficiency in verbalistic and numerical reasoning.

Based on observations made during stoichiometry instruction, there is insufficient student participation in the learning process. Low student involvement in the learning process can be due to several of factors, such as: 1) students' relatively low prior knowledge in verbalistic and numerical reasoning; 2) students' reluctance to ask questions, make comments, or express their opinions in order to connect and develop the concepts they have learned; and 3) students' inability to explore their own experiences and build shared experiences when working in a team [1].

A lecturer teaching a course must be able to provide learning activities and scientific work stages that will promote students' active engagement in the learning process so that stoichiometry can be understood in three forms: macroscopic, microscopic, and symbolic [2] Scientific work steps and learning activities in the learning process require a series of prior knowledge in the form of generic science skills [3] Verbal reasoning and numerical reasoning ability tests can be used to evaluate students' prior knowledge and reliable indicators of measuring students' ability to complete scholastic tasks that are truly required in the learning process [4].

Prior knowledge as an indicator of learning readiness must be identified so that the learning process can be adjusted to the requirements. Students' generic science skills is very significant in the learning process since it improves student engagement and the role of lecturers as facilitators during the learning process.From the results of research conducted by Sinaga in 2018, teaching materials which is equipped with students' activity sheets in general chemistry learning using the 5E learning cycle (Engagement, Exploration, Explanation, Elaboration, and Evaluation) can increase student involvement and interaction in the learning process.

Lecturers can help students who are having trouble understanding teaching materials by offering scaffolding during the students' activity sheets work. They can also reinforce concepts and teach students how to use the 5E learning cycle to solve problems from various perspectives [5-6]. The process of completing a students' activity sheets and combining many generic science skills simultaneously can enhance critical thinking skills [1]

Implementation of stoichiometry learning design using learning tools consisting of: 1) semester learning plan; 2) prior knowledge evaluation in the form of numerical reasoning and verbalistic reasoning tests; 3) teaching materials equipped with learning objectives, narratives, and example questions according to the main or sub-topic subject to be studied; 4) students' activity sheets contains an integration of a number of generic science skills that are carried out after learning takes place; and 5) evaluation of learning outcomes which is carried out at the end of learning, is one alternative to increase student involvement in learning.

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Formulation of the problem

Based on the background of the problem that has been stated, the problem formulation in this research is as follows:

1. How to design stoichiometry learning to increase student involvement in the learning process?
2. How to improve students' generic science skills in stoichiometry learning?
3. How to integrate several generic science skills at once into one student activity sheet in stoichiometry learning that can improve students' critical thinking skills?
4. Do prior knowledge evaluation results and student activity sheet results affect students' critical thinking abilities?

Research methods

The process of designing stoichiometry learning involves three steps: 1) needs analysis, 2) creating and implementing learning designs, and 3) assessing the outcomes of learning designs. This approach aims to fulfill the five fundamental principles that define the process of learning, which are: a) students solving real-world problems, b) activating prior knowledge as a foundation for new knowledge, c) students being taught new knowledge, d) students implementing new knowledge, and e) students integrating new knowledge into their lives [8,9]

The needs analysis stage is carried out based on observations collected while carrying out learning and examining documentation on learning outcomes from previous years' mid-semester examinations and final semester examinations.

Based on the results of the needs analysis, a stoichiometry learning tool was prepared and produced, which included: 1) semester learning plan; 2) prior knowledge evaluation in the form of a numerical reasoning and verbalistic reasoning test instrument; 3) teaching materials equipped with learning objectives, narratives, and examples of questions related to the main or sub-topic subject to be studied; 4) students' activity sheets includes the integration of a number of generic science skills, which is done after the learning is completed; and 5) evaluation of learning outcomes, which is done at the end of the learning.

According to Meril's 1983 theory, known as Component Display Theory (CDT), there are two dimensions of learning objectives: content type dimensions and performance level dimensions. The learning content in teaching materials is divided into four categories: (1) facts, (2) concepts, (3) procedures, and (4) principles. Meanwhile, there are three categories of performance level: (1) remembering facts, (2) remembering concepts, finding concepts, (3) remembering procedures, utilizing procedures, remembering principles, using principles, and finding principles. [10]

Teaching material is a crucial learning tool in the compilation of other learning tools. The narrative, systematics, and example questions in the teaching material are adjusted to the generic science skills expected by the learning objectives, and the generic science skills are developed in the student activity sheets by considering three aspects of quality, namely: 1) material content, 2) construction, and 3) language and learning strategies REACT (Relating, Experiencing, Applying, Cooperation, and Transfer) [11]

At the learning design implementation stage, the learning process begins with prior knowledge evaluation as part of learning readiness in the form of numerical reasoning and verbalistic reasoning tests that are relevant and support the achievement of learning objectives in the semester learning plan, then continues with delivering teaching materials and completing students' activity sheets through the 5E learning cycle, and ends with the implementation of evaluation of learning outcomes. In a learning activity, prior knowledge needs to be mapped first with the consideration that: 1) most of the knowledge concepts used are undefined or

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vaguely defined; 2) nominal definitions trump actual definitions; and 3) different aspects of science are referred to with the same terms, or the same aspects of science are referred to with different terms [12]

Prior knowledge, which includes declarative and procedural knowledge required for stoichiometry learning, can be assessed using verbalistic reasoning and numerical ability test instruments. Verbal reasoning is a general cognitive ability to obtain information, while numerical ability is the ability to understand number relationships [13]

The prior knowledge evaluation results are used as a reference for grouping students in completing the student activity sheets. The duration of time required to implement the stoichiometry learning design is: a) carry out the prior knowledge evaluation and discuss it for 10-15 minutes; b) deliver the teaching materials for 60 minutes; c) fill in the student activity sheets and observe it for 15-20 minutes; and d) perform evaluation of learning outcomes for 10 minutes. The involvement of lecturers and students in the 5E learning cycle is observed by using an observation format with 4 rating scales (1 = poor, 2 = fair, 3 = good, and 4 = excellent) when lecturers teach and students take part in learning and complete the students' activity sheets.

The evaluation of learning outcomes tool is designed to accomplish learning objectives in the form of standard multiple-choice questions with five possible answers. Students' critical thinking abilities can be measured using the evaluation of learning outcomes tool through the critical thinking ability indicators proposed [14].

Research hypothesis

The research hypothesis on the implementing of prior knowledge evaluation and the 5E learning cycle in stoichiometric learning design to improve students' critical thinking skills is as follows:

1. Package; prior knowledge evaluation, teaching materials, students' activity sheets, and evaluation of learning outcomes are align with learning objectives and can increase student involvement in the stoichiometry learning process.
2. Device; teaching materials, students' activity sheets, and evaluation of learning outcomes can develop students' generic science skills through the 5E cycle in learning stoichiometry.
3. Integrating several generic science skills at once into one students' activity sheets can improve students' critical thinking skills in learning stoichiometry.
4. The prior knowledge evaluation and students' activity sheets results have a significant effect on the evaluation of learning outcomes results in learning stoichiometry.

Research results and discussion

Assessment in terms of REACT quality and strategy on teaching materials and student activity sheets, consist of 4 assessment scales, which are: 1 = poor, 2 = fair, 3 = good, and 4 = excellent. The assessment format in terms of teaching materials and students' activity sheets quality used by expert validators consists of 13 statements, with 4 statements of content aspects, 6 statements of construction aspect and 3 statements of language aspect.

The REACT strategy assessment format is designed by modifying the National Education Standards Agency (BSNP) assessment format to acquire 15 statement items. Relationship of teaching materials or student activity sheets with: 1) students' life experiences (Relating, R), which consist of 6 statements; 2) students' experiences in exploring teaching materials (Experiencing, E), which consist of 2 statements; 3) the use of teaching materials or students' activity sheets in overcoming various problems related to student life (Applying, A),

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which consist of 2 statements; 4) cooperation between students through group learning (Cooperation, C), which consist of 2 statements; and 5) use of knowledge in new situations (Transfer, T), which consist of 3 statements.

The average results of three expert validators' assessments of quality and strategy of REACT from teaching materials and students' activity sheets in stochiometry learning are 89.73 and 91.13. Based on the findings of this evaluation, it is possible to conclude that teaching materials and students' activity sheets are excellent tools for use in the learning process.

According to observations during Stoichiometry learning design experiments in small classrooms (37 students) over two sessions, the proportion of student involvement during the teaching materials delivery process and completion of practice questions on students' activity sheets during the 5E cycle was relatively low. Only 19% and 35% of students in the excellent category were able to lead the example questions on teaching materials, while 41% and 57% were able to follow the flow (stages) of completing the students' activity sheets with numerous steps in the excellent category. Students' ability to ask questions, comments or opinions in connecting and developing concepts that have been studied with other related concepts and the ability to explore each other's experiences and build shared experiences when working together in teams to complete student activity sheets in the excellent category is only 19% and 24%. %.

Table 1. Percentage of observation results of students in Stoichiometry learning during two meetings

No	Description of observed aspects	Meeting 1				Meeting 2			
		E	G	F	P	E	G	F	P
1	Students are actively involved during the learning process	41	59	0	0	43	35	22	0
2	Students ask questions, comments or opinions if they experience difficulty in connecting and developing the concepts they have learned with other related concepts	24	49	27	0	24	30	46	0
3	Students can follow the example questions in the teaching materials in solving practice questions in the students' activity sheets	19	68	14	0	35	54	11	0
4	Students are able to explore each other's experiences and build shared experiences when working together in teams to complete students' activity sheets	24	54	22	0	14	65	22	0
5	Students need help with scaffolding techniques from the lecturer in completing the students' activity sheets	46	22	32	46	30	49	22	0
6	Students can follow the flow (stages) of completing the students' activity sheets with many steps.	11	35	54	0	35	62	3	0
7	Students can follow the flow of learning activities in a coherent, systematic manner and according to the time allocation	41	35	24	0	57	22	22	0

Note: E = Excellent, G = Good, F = Fair, P = Poor

The low level of student involvement in filling out the students' activity sheets is thought to be due to: 1) students' low level of verbalistic reasoning in understanding statements and questions in the student activity sheets, which includes principles; a) basic laws of chemistry; b) masses of elements that make up a compound; c) the concept of moles; d) procedures for completing reaction coefficients; and e) determining the limiting reagent in a

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reaction equation; 2) students' low level of numerical reasoning involving number operations (addition, multiplication, and division) and creating a solution model; 3) there are no students in the group who can act as peer tutors; and 4) lecturers who teach courses cannot maximize their role as facilitators through scaffolding techniques in the learning process due to limited verbalistic and numeric reasoning from students. The results of observations of students in stoichiometry learning during two meetings are shown in Table 1.

Students inability to complete students' activity sheets in groups that require the integration of multiple generic science skills at once is characterized by: 1) a small number of students asking questions, comments, or opinions; 2) students having difficulty connecting and developing the concepts they have studied with other related concepts; and 3) there are still students' activity sheets that are not filled (empty). This inability will have a direct impact on their ability to complete the evaluation of learning outcomes, which is done separately.

From the results of stoichiometry learning design trials during two meetings in small classes (37 people), the average prior knowledge evaluation results were; 55.68 ± 16.92 and 72.92 ± 22.09. The average students' activity sheets results were 57.57 ± 15.97 and 87.03 ± 11.75 and evaluation of learning outcomes results were 52.97 ± 17.14 and 88.11 ± 14.57.

After the learning process is complete, students' critical thinking abilities are measured using the evaluation of learning outcomes tool with 10 questions through indicators of critical thinking abilities proposed [14], which include: 1) answering questions, 2) using established procedures, 3) identifying or formulating criteria to decide on possible answers, 4) looking for similarities and differences, 5) deducing and considering the results of the deduction, interpreting the results, 6) analyzing opinions looking at similarities and differences, and 7) identifying an opinion or assumption.

The description "deducing and considering the results of the deduction, interpreting the results" is one of the critical thinking abilities indictaor that requires various steps by integrating several types of generic science skills at once in an evaluation of learning outcomes and/or evaluation of learning outcomes.

For example, 1.6 grams of rock containing copper were dissolved in an excess of concentrated HCl. All copper ions (Ar Cu = 63.5) in this solution are precipitated as copper sulfide (Ar S = 32). If the mass of the sediment obtained is 0.48 grams, then the copper content in the rock is...

A. 60% B. 40% C. 30% D. 20% E. 10%

This question item is a regular multiple choice with 5 alternative answers. In order to complete this evaluation of learning outcomes correctly, students must have good reasoning starting with verbalistic reasoning about; 1) the mass of copper in the rock sample is the same as the mass of copper in copper sulfide (CuS) in accordance with the concept of Lavoisier's law in a chemical reaction, that the mass of the substance before and after the reaction is the same, 2) the mass ratio of Cu to CuS is in accordance with the concept of chemical formulas and then continues with numerical reasoning through the application of numbers whose solutions are in the form of number operations: addition, multiplication and division, then calculate the mass of copper contained in 0.48 grams of copper sulfide using the concept of the law of mass ratio of the elements that make up a compound and calculate the copper content contained in a rock sample which requires generic science skills in the form of; symbolic language, cause and effect laws and mathematical modeling. The solution to these questions is as follows:

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$$Mass\ Cu_{\ in\ rock} = mass\ Cu_{\ in\ CuS}$$

$$Mass\ Cu_{\ in\ CuS} = \frac{Ar\ Cu}{Mr\ CuS}\ x\ mass\ CuS = \frac{63,5}{95,5}\ x\ 0,48\ g = 0,32\ g$$

$$\%\ Cu_{\ in\ rock} = \frac{0,32}{1,6}\ x\ 100\% = 20\%$$ (Answer: D)

The distribution of students' critical thinking abilities in Stoichiometry learning is shown in table 2.

Table 2. Distribution of students' critical thinking abilities in stoichiometry learning

No	Description of Critical Thinking Indicators	Question number	The correct amount	%
1	Answer the question	2	8	22
2	Use established procedures	4 and 6	55	74
3	Identify or formulate criteria to decide on possible answers	5 and 7	65	88
4	Look for similarities and differences	1	15	41
5	Deducing and considering the results of the deduction, interpreting the results	8 and 9	36	49
6	Analyze opinions to see similarities and differences	10	24	65
7	Identify an opinion or assumption	3	21	57
	Average			**56**

Although the average of critical thinking ability in learning Stoichiometry is in the poor category (56%), students need to be guided to solve the questions contained in the student activity sheets with a solution framework that requires many steps. A framework for solving questions that requires many steps is one of the characteristics by students who have critical thinking skills [15].

In order to process the double regression equation of influence of the independent variables (Prior Knowledge Evaluation, PKE and Students' Activity Sheets, SAS) on the dependent variable (Evaluation of Learning Outcomes, ELO) used the IBM SPSS Statistics 22 program to obtain the regression equation, ELO = 26.627 + 0.127 PKE + 0.494 SAS. Based on the Anova table, obtaining the F value of 4,287 with a Sig. value of 0,022 (< 0,05) can be concluded that the linear line equation and the coefficient of the equation regression is significant and there is no multicollinearity between the independent variables, with a coefficient of determination (r^2) = 44.9%, which means that 44.9% of the variables in the evaluation of learning outcomes results can be explained by the prior knowledge evaluation and student activity sheets results variables and the rest by other factors not studied.

Conclusions and recommendations

Conclusions

From the results of the research entitled "Implementing of prior knowledge evaluation and the 5E learning cycle in stoichiometry learning design to improve students' critical thinking skills" it can be concluded that:

1. Learning tools have been obtained, which are; a) prior knowledge evaluation, in the form of verbalistic reasoning and numerical reasoning test instruments, b) teaching materials, c) student activity sheets, and d) evaluation of learning outcomes which are in accordance with stoichiometry learning objectives.

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2. Device; teaching materials, students activity sheets, and evaluation of learning outcomes can develop students' generic science skills through the 5E cycle in learning stoichiometry.
3. Implementation of stoichiometry learning design with the prior knowledge evaluation strategy and 5E learning cycle can increase student involvement and learning outcomes as students in the learning process.
4. The prior knowledge evaluation and generic science skills results have a significant effect on the evaluation of learning outcomes results in learning stoichiometry.
5. Although student involvement in constructing new knowledge during learning is in the low category, if implemented continuously, this learning design is believed to be able to foster the students' learning culture and critical thinking skills.

Recommendations

In order to increase student engagement and learning outcomes in advanced chemistry classes and other courses, it is required to test out learning designs that use the prior knowledge evaluation method and the 5E learning cycle.

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A theoretical review towards the use of simulator in mathematics learning at university

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Abstract. *This paper attempts to discuss theoretically about the use of simulators in mathematics education, especially at university level. It seeks to provide a brief overview towards the advantages, disadvantages, and theoretical interventions of using simulators in math teaching and learning process. In recent years, simulators have become popular instrument and effective tool for improving the quality teaching and learning for a wide range of academic subjects. In the realm of mathematics education, simulators provide an engaging and innovative environment for students to deal with situated problems and explore mathematics with their own. In this case, many researchers see the potential of simulators to close the knowledge gap between abstract mathematical ideas and practical applications is examined in this abstract. This study explores the pedagogical ideas that support the successful use of simulators in mathematics learning through an extensive review of the literature. It looks at ideas like contextual learning, constructivism, and cognitive load theory to explain how simulators might help students become more actively involved in their education and build their conceptual knowledge and problem-solving abilities. The abstract also discusses the difficulties and factors to be considered while creating and utilizing simulators in mathematics education, such as technology needs, instructor support, and methods for assessment and feedback. The purpose of this theoretical review is to add to the current conversation about cutting edge methods of instruction in mathematics education. It encourages the incorporation of simulators as useful aids in boosting mathematics learning at the university level by examining the theoretical underpinnings and going over the possible advantages and difficulties.*

Keywords: Mathematics learning, simulator, university level, theoretical analysis.

Introduction

The integration of technological devices in mathematics education has currently gained much attention among educators due to its importance as a powerful instrument to support teaching and learning process [22]. The role of simulators offers a vibrant and interactive learning circumstance that can possibly engage students to participate in an active mathematics-problem discussion along the classroom experience [11]. Consequently, this paper highlights a further theoretical description about technological interventions in mathematics learning at university and aims to provide better understanding of the theoretical foundations, benefits, and challenges in implementing simulators in the mathematics curriculum.

Many studies have been conducted to document the important use of technology in mathematics learning [11,4]. This is due to its potential to eliminate the gap between the abstract mathematical conceptions and the situated contextual problems [7]. By embedding technological environments in students' mathematics learning, simulators allow them to

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experience the practical connections of a mathematical theory and its applications in real-world setting [23]. Through a comprehensive literature review, this current study attempts to explore the pedagogical theories which underline the effective use of simulators in teaching mathematics at university, involving the constructivism philosophy, cognitive aspects, and learning design.

In mathematics classroom, one of the critical advantages of simulator embedment is the positive influence as it can promote active student engagement [23]. In this case, simulator can support university students to learn mathematics optimally by facilitating them with individual learning process [2]. By enabling students to modify with their own works, such as manipulating variables, analyzing outcomes, and conducting experiment within the simulated environment, simulators offer opportunities for students to construct their knowledge and understanding towards the mathematical ideas [1].

Moreover, another advantage of simulator in mathematics teaching and learning lies on its ability to foster students' conceptual understanding [20]. The current teaching methods at university often rely on delivering abstract representations and making it more challenging that the students find difficulties to grasp the complex mathematical ideas [12]. Simulators, in this case, can make students communicate and interact with the mathematical concepts meaningfully [9]. Thus, the students are possible to acquire a deeper understanding towards the mathematical subject. Current research findings show that simulators also play an important role in the development of problem-solving skills [3]. By providing simulated mathematical circumstances for exploration and experimentation, students can apply the mathematical theories to deal with context-based problems [21]. This teaching approach will nurture students critical thinking, analytical reasoning, and creativity, which are claimed as essential skill for their academic career in the future.

Although many educators have seen the important use of simulators in mathematics learning; however, the introduction of simulators in mathematics education finds many challenges among educators. Designing a simulator-based learning experience requires detail consideration of assessment and response procedure, technological constraints, and support from instructors [5]. Furthermore, observing the validity of simulator's accuracy and selecting the appropriate feedback mechanisms are crucial to maintain the implementation of the mathematical simulator [14]. Therefore, this theoretical review contributes to the constant discourse on innovative teaching and learning process in mathematics education through conducting explorations to the foundations, advantages, and challenges in terms of simulator embedment in the university-level curriculum.

Embedding Simulator in Mathematics Learning at University

The intervention of simulators in mathematics learning at the university level has gained much attention to improve the quality of teaching and learning experiences [22]. In this case, simulators provide a progressive and interactive learning environment that potentially engages students to conduct exploration in solving situated. This section aims to describe the effectiveness and challenges related to embedding simulators in mathematics classroom at university, providing several instances to outline their beneficial aspects and limitations.

Effectiveness of Simulators:

Simulators have shown a significant impact to bridge the gap between complex mathematical knowledge and situated contextual problems [4]. For example, a closer look can be seen

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in calculus, simulators can be settled to capture the authentic fragments such as the movement of some objects or the increasing number of populations in a local area. By communicating with these simulation instruments, it is possible for the students to delve deeper to have a better understanding of how to apply the mathematical algorithms to practical circumstances [19]. During the learning process, the students can explore distinctive scenarios, manipulating variables, and observing the outcomes, to delve further the essence of mathematical topics.

Simulators have proven to be valuable aids in linear algebra, enabling students to visualize abstract concepts like vector spaces and transformations [17]. For instance, simulators provide real-time manipulation of vectors, allowing students to witness their linear combinations, which concretely exemplifies the underlying mathematical principles. This interactive approach enhances students' spatial reasoning and comprehension of how geometric shapes and structures are influenced by linear transformations. Additionally, simulators are highly suitable for probability and statistics courses as they facilitate the exploration of probability distributions through the simulation of random events or more scientific experiments [16]. These simulations enable students to grasp concepts related to sampling and inference, while also providing a controlled environment to analyze and investigate data, thereby aiding in the development of statistical reasoning and decision-making abilities.

In more global scale, simulators offer opportunities to create a collaborative learning to solve problems, especially in mathematics courses at university that revolve around iterative processes through logical thinking [13]. By collaborating with fellows, students can extensively tackle difficult problems by developing various strategies [16]. in this moment, simulators allow students to observe and analyze the impacts of construing different approaches, promoting group discussions and fostering the development of collective problem- solving skills and knowledge.

Challenges and Limitations:

Beside their potential works, embedding simulators in mathematics learning is truly taking times that educators often face many challenges and obstacles. One significant challenge is the need for appropriate assessment methods [23]. Traditional assessment approaches, such as written exams or problem sets, may not fully capture the skills and knowledge acquired through simulator-based activities. Instructors must design assessment strategies that effectively evaluate students' ability to apply mathematical concepts within simulators while still ensuring a comprehensive assessment of traditional mathematical knowledge and problem-solving skills.

Another constraint lies in designing ready-made simulators that align with a specific educational target. Creating these simulators require detail experiences in designing and developing accurate representations of the mathematical concepts [20]. For instance, designing a simulator that models complex mathematical processes, such as differential equations, requires expertise in both mathematics and educational technology. Developing such simulators can be time-consuming and resource intensive. Technological requirements and accessibility represent additional challenges. Simulators often require advanced hardware and software, potentially limiting their availability to students who lack access to the necessary equipment or have limited technological literacy [19]. To provide equitable access to simulators and avoid aggravating already-existing educational inequities, universities must address these discrepancies.

Additionally, developing fundamental mathematical skills can be stimulated by an excessive dependence on simulators. Simulators should be utilized as an addition to traditional training, not as a replacement for it. A balance between simulator-based activities and traditional mathematical

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methods need to be achieved for students to fully understand basic ideas and problem-solving techniques [11].

Examples of Integrating Simulators:

The exploration of geometric concepts using dynamic geometry software, such GeoGebra or Desmos, is an example of incorporating simulators into mathematics education. With the aid of these resources, students can work with shapes, investigate geometric connections, and see how various transformations impact figures. Students can improve their geometric intuition and comprehend geometric principles and theorems more thoroughly by employing simulators.

The incorporation of computer algebra systems (CAS) into calculus classes is an additional illustration. Students can manipulate equations, graph functions, and do symbolic computations using CAS software such as Wolfram Mathematica or Maple. Students can investigate intricate mathematical expressions, solve equations quickly, and depict calculus ideas with the help of CAS. With the use of CAS simulators, students can experiment and solve increasingly complex problems, allowing them to investigate mathematical concepts beyond what is possible with pen and paper calculations. Simulators can be used in statistics classes to demonstrate ideas like sample distributions and hypothesis testing. For example, to illustrate the concepts of statistical inference, a simulator can produce random samples again and time again. Students can examine sample variability and have a deeper knowledge of statistical topics through this practical practice.

As a result, although the use of simulators in university-level mathematics instruction has potential, there are drawbacks and difficulties. By bridging the gap between abstract mathematical ideas and practical applications, simulators can promote problem-solving abilities, group learning, and a deeper comprehension of the subject matter. But it's also important to make sure that the right assessment techniques are used, to meet accessibility and technology needs, and to avoid relying too heavily on simulators. Embedded simulators can be used to enhance mathematics instruction; some examples of these include statistical simulators, computer algebra systems, and dynamic geometry software. By carefully incorporating simulators as extracurricular resources into the curriculum, educators can offer engaging and effective learning experiences that support the growth of basic mathematical ideas and conceptual understanding.

Beneficial Aspects of Simulator Integration

It has been acknowledged that the use of simulators in a variety of educational settings can improve student learning. Simulators give users hands-on experiences in dynamic, interactive environments that let them explore and interact with difficult subjects. Examining the advantages of simulator integration in educational settings and offering instances to support their efficacy are the goals of this critical examination.

Enhanced Engagement and Active Learning:

Encouraging student participation and active learning is a major advantage of incorporating simulators. With the use of simulators, students may engage with virtual worlds, changing parameters and seeing results instantly [8]. In addition to piquing students' curiosity, this interactive method motivates them to actively participate in their education. Simulators, for example, can let students conduct virtual experiments in science classes that might not be possible or safe to carry out in a regular laboratory setting. Students can test theories, investigate numerous scenarios, and see how different elements affect the results of experiments by using the simulator. Students that actively interact with the simulator gain a thorough comprehension of scientific ideas and procedures in addition to developing their critical thinking abilities [18].

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Simulators also allow students to practice and hone their skills in a controlled virtual environment in technical professions like engineering and aviation [6]. Aspiring pilots, for example, might practice making decisions by using flight simulators to experience realistic flight scenarios and handle challenging situations. These domains' simulators offer beneficial possibilities for hands-on learning that boost students' proficiency and self- assurance in their chosen subjects.

Practical Application of Knowledge:

Simulator integration helps close the gap between abstract ideas and actual situations by facilitating the practical application of academic knowledge. By virtual environments, students can gain a better understanding of how their academic knowledge is used in real-world situations [10]. Simulators are vital resources in medical education that help prepare future medical practitioners. With the use of medical simulators, students can hone their diagnostic and procedural abilities in a secure setting [15]. Surgical simulators, for instance, enable budding surgeons to practice procedures, enhancing their coordination, dexterity, and judgment. The ability to build competence, efficiency, and critical thinking skills necessary for clinical practice can be greatly enhanced by simulation-based training.

Education in business and management also heavily relies on simulation. Using virtual business scenarios, business simulations give students the opportunity to manage resources, make decisions, and consider the effects of their choices. Students can apply theoretical principles, including financial decisions or marketing tactics, in a practical context by using a simulated business environment. Their comprehension of business ideas is reinforced by this real-world application, which also fosters the development of their problem-solving abilities and strategic thinking.

Enhanced Accessibility and Flexibility:

Integration of simulators can improve accessibility in education and get around logistical issues. Virtual simulations provide time and geographical flexibility, opening educational opportunities that might otherwise be inaccessible. For instance, in geography classes, simulators let students do geographical studies and virtually explore different environments without requiring lengthy field excursions. Students can study landforms, investigate topographic characteristics, and observe geographic trends using the simulator. By offering a practical and affordable substitute, simulators enable geographical learning to extend beyond the walls of a traditional classroom.

Furthermore, the incorporation of simulators can facilitate customized and flexible learning encounters. Sensitive simulations can adjust to the specific requirements of each learner, offering customized feedback and learning help. Students can practice at their own speed, focusing on areas of weakness and strengthening their comprehension of difficult subjects through individualized simulations.

Consequently, the incorporation of simulators offers numerous benefits to educational settings, including enhanced accessibility, increased student engagement, and practical application of acquired knowledge [4]. In this case, simulators are possible to immerse students in vibrant and interactive virtual circumstances, which can create active teaching and learning process, develop critical thinking, and foster the development of practical capabilities. Several examples of these situations can be obviously seen in science experiments, business simulations, surgical simulations, and geography assessments that shows the effectiveness of simulator embedment across many disciplines.

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The limitations and challenges associated with the integration of simulators must be considered. These include the need for adequate technological resources, the development of realistic and high-quality simulations, and the assessment of learning objectives. By carefully weighing the benefits and drawbacks, teachers can make the most of simulator integration to create engaging, realistic, and conveniently available learning opportunities that enhance students' competencies.

Challenges in Implementing Simulators Within Mathematics Curriculum

The simulator is a helpful tool for enhancing student learning in several topics, including mathematics. Simulations facilitate students' understanding and application of abstract mathematical topics by providing a dynamic and interactive means of exploring mathematical ideas. However, there are a few concerns with the inclusion of simulators in mathematical curricula that must be carefully considered. This critical study looks at these issues and offers examples to show how difficult it can be to deploy simulators successfully.

Accessibility and Technical Requirements:

Ensuring accessibility for all students is a major difficulty when integrating simulators into the mathematics curriculum. Specific technical skills and resources, such as computer hardware, software, and dependable internet connectivity, are frequently needed for simulators. Not every student may have easy access to these prerequisites, especially in disadvantaged schools or areas. As a result, the usage of simulators may inadvertently contribute to a wider digital gap by reducing opportunities for fair education. For instance: Examine a simulation that simulates projectile motion paths. Although this simulator offers insightful information on the intricate dynamics involved, students without access to computers or the required software will not be able to use it. This restriction could make it more difficult for them to understand and have a bad effect on their entire educational process.

Curriculum Alignment with Simulators:

Ensuring a seamless integration of simulators within the existing mathematics curriculum poses another significant challenge. Simulators should complement the curriculum objectives and align with the desired learning outcomes. However, the development of high-quality simulators that effectively address specific mathematical concepts can be time-consuming and resource intensive. Additionally, curriculum developers and educators must strike a careful balance between the interactive nature of simulators and maintaining the rigor and depth necessary for mathematical understanding [20]. Example: Consider a simulation designed to demonstrate the concept of exponential growth in the context of population dynamics. If the simulator oversimplifies the intricate mathematical principles behind exponential functions to encourage ease of use, it may compromise the depth of understanding students can achieve. This discrepancy between the capabilities of the simulator and the curriculum objectives can result in confusion and misconceptions among students.

Assessment and Evaluation:

Integrating simulators into the mathematics curriculum necessitates thoughtful consideration of assessment methods. Traditional assessment approaches, such as exams and worksheets, may struggle to capture the skills and concepts acquired through simulator-based learning. Evaluating students' proficiency in utilizing simulators effectively can be a complex task. Educators need to develop new assessment strategies that measure both procedural skills and conceptual understanding while embracing the potentials afforded by simulators [21].

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Example: Imagine a scenario where a teacher assesses a student's understanding of calculus solely through written examinations, disregarding the significant insights gained through a calculus simulator. This assessment oversight not only fails to recognize the student's ability to apply calculus concepts in practice but also disincentivizes the use of simulators as a learning tool.

Conclusion

It is necessary to consider the restrictions and difficulties related to the integration of simulators. These include the requirement for sufficient technology resources, the creation of excellent and lifelike simulations, and the evaluation of learning goals. Teachers can use simulator integration to create realistic, convenient, and engaging learning opportunities that improve students' competencies by carefully assessing the advantages and disadvantages.

Therefore, the constant discourse on innovative teaching and learning process in mathematics education through conducting explorations to the foundations, advantages, and challenges in terms of simulator embedment in the university-level curriculum are essentially important.

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Rewang culture-based learning in cooperative learning models with OBE approach

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Abstract. *Learning with an Outcome Based Education (OBE) approach focuses on student achievement in knowledge, skills and attitudes. Rewang culture is one of many cultures in Indonesia that teaches many things, especially in attitude and how to work together in achieving the same goal. Applied using the Cooperative Learning model, this study uses interview methods and focus group discussion (FGD) in evaluating strategies designed using the OBE approach. Furthermore, the data that has been successfully collected, analyzed to be able to understand and get conclusions. Applied to two math classes, the learning process using Rewang culture-based strategies accelerates the learner's self-learning process and accelerates the acquisition of knowledge in groups. But it is not without obstacles, the results of data collection state that the role of teachers or in Rewang culture is the chief executive plays an important role in the course of the learning process. Punctuality and assignment according to ability are also considerations in determining the composition of members in a group.*

Keywords: Learning strategies, Rewang Culture, Cooperative Learning models, OBE, qualitative research.

Introduction

Outcome Based Education (OBE) is an approach that emphasizes the sustainability of the learning process in an innovative, interactive and effective manner. In the process, OBE includes alignment between the curriculum, formulation of learning objectives and outcomes, educational strategies, design of learning methods, assessment procedures and the environment or ecosystem of Education. The gap between the world of education and the needs of human resources in the world of work and society is caused by the rapid pace of technology utilization and innovation production so that the world of education must catch up. OBE is an approach to education and learning systems with a focus on the outcomes of a learning process. Through the OBE approach, it is hoped that learning will be more directed, and the graduates produced are in line with the needs of users and the community. The findings revealed that students had a positive attitude towards OBE [8]. Learning with the OBE approach assumes that experiences are more valuable than memories [7].

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OBE plays a role in improving innovation skills and teamwork skills [10]. But not only to produce things needed by modern society, but this study also wants to touch traditional parts of people's lives. To balance this, culture-based learning is used where there are many things that can be touched, not only from the cognitive side but also from the skill and attitude side. The use of culture-based learning is also able to improve critical thinking and communication skills of students in study groups [3]. Culture-based learning can increase learners' engagement and knowledge about their own culture [6]. However, the cultural diversity of students who come from many cultures makes learning even richer in variety. Steps in culture-based learning organized in multicultural classrooms also have a significant effect in multicultural development [5].

The benefits of this learning are things that want to be produced in learning in the Mathematic classroom. Culture-based learning can improve the problem-solving ability of early semester students [1]. Based on these things, a culture-based learning strategy was developed using one of Java's cultural traditions that involved the team in the implementation process. This tradition is the Rewang tradition where this tradition can be used for the development of social psychology perspectives. This tradition was chosen to touch the social sense of solidarity between communities which is also needed in the world of society [9].

Methodology

This study employed a qualitative approach. Several surveys were conducted as observations to see whether learning without the OBE approach produces skills that students can have. The observations stated that: (1) 66.67% of students learn to understand learning but do not have outcomes in the form of skills or the ability to solve stakeholder problems, (2) 51.11% of students cooperate in learning but are not satisfied with the distribution of tasks, (3) students still learn to remember by rote, not by doing so that they only have short memory of the learning that has been done [2] shows on their research that culture-based learning has the potential to be applied to create quality human resources in Indonesia because it not only provides benefits in aspects of knowledge but also academic attitudes and behaviors, strengthens the existence of local culture and even integrates the values contained in that culture. Learning strategies that are cooperative learning in the form of culture-based learning are chosen to preserve culture. Adopt the principle of cooperation in the Rewang tradition of Javanese culture. This research aims to use the principle of cooperation in the Rewang tradition to produce learning that produces skills that are in accordance with the competencies of graduates to be achieved.

Culture-Based Learning: Rewang

Rewang is a helping activity carried out by the people of Java, Indonesia, when there is a person or family who celebrates. Rewang is also used as a determinant of the success of a celebration. If the rewang goes well, the event can run successfully, and vice versa. The values that emerge from the rewang tradition are that Javanese people are aware that life must involve or need others. Javanese people do not position themselves as individuals who can do all things. The social values that emerge are a sense of brotherhood that is upheld, unity and cooperation. The rewang process is carried out by grouping the people who will do the rewang. The division of tasks is made on the basis of groups that have been formed. However, the division of the group is carried out not by the owner of the celebration but by the neighborhood leader as the head of the community who helps or works together. The neighborhood leader is also responsible for ensuring that all tasks are carried out properly. The neighborhood leader distributes tasks to a group of people regardless of age or social status. Grouping is tailored to its potential and many groups are adapted to its many

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tasks. The number of group members does not have to be the same but adjusted to the needs according to the task to be performed.
In each assignment group there are problems that must be solved in groups with the following description in each group.

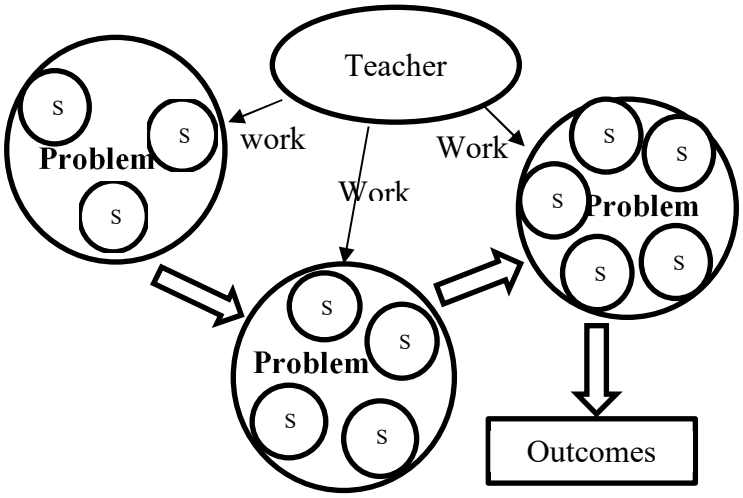

Figure 1. Rewang tradition as Learning Strategy

The teacher replaces the role of the neighborhood leader in leading the learning process. Teams are divided into groups, depending on the needs of the desired outcomes. Assignments are carried out based on student abilities. The number of groups does not have to be the same, depending on the number and complexity of problems assigned to each working group.

Outcome Based Education (OBE)

The goal of this research based on OBE approach is the student achievement in every learning that takes place. Learning objectives related to the needs of stakeholders become a reference for teachers to determine learning strategies so that students obtain learning outcomes in the form of skills needed by stakeholders. By using Rewang's culture-based learning strategy on learning, it was carried out in two mathematics classes in higher education with the OBE approach. This learning strategy is a strategy implemented through learning groups that have a goal in each group and is part of the intended learning outcomes. The indicator on the effectiveness of Rewang's culture-based learning strategy is described as follows:

Table 1. Indicator for Rewang Culture as Learning Strategy with OBE approach

	Stakeholders needs	Student in Class	Teacher in Class	Effective process	Learning Objective achievement
Cognitive	Skill and knowledge	Provide maximum learning outcomes	Provides maximum learning	Discuss outcomes	Achieved
Affective	Good Sosial behaviour	Discuss and giving opinion clearly and patiently	Assess through the process	Self - adjustment	Achieved
Psychomotor	Skill and dexterity	Interaction	Active	Active	Achieved

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This indicator is used to see whether Rewang culture-based learning can be used as a learning strategy applied with the OBE approach.

Data collection was obtained from the results of interviews and questionnaire with students, group discussion forums involving 3 teachers who observed the course of the learning process (knowledge and psychomotor), 8 observations during the learning process using this strategy were carried out (affective) and based on the outcomes that could be obtained.

Results and Discussion

The results of the student satisfaction questionnaire after implementing this strategy 8 times, summarized and presented in the following table:

Table 2. Results of student satisfaction questionnaire on learning with Rewang strategy

Indicator	Percentage	
	Class I	Class II
Ease of issuing opinions	60% increase to 71,11%	57,78% increase to 66,67%
Ease of interaction	68% increase to 75,55%	60% increase to 64,44%
Ease to explore capabilities	48% increase to 53,33%	46,67% increase to 62,22%
Difficulty in understanding the subject	48,88% decrease to 40%	55,55% decrease to 40%
Appropriateness of time required in interaction	88%	86,67%
Suitability of the role of lecturer in learning	66,67% increase to 84,44%	60% increase to 82,22%

Some interviews with students stated that the application of this strategy allows students to prepare themselves in advance before the learning process begins. Because if you don't have the readiness, then the knowledge to use in discussing and solving problems becomes very lacking. 48.88% of students said that it was difficult to understand the material and show learning outcomes because they had little preparation before learning began. But it feels more directed when you have preparation in understanding the material first. One of the learning methods applied is to apply the discovery learning method and carried out in groups with the Rewang learning strategy, it was found that students were easier to explore abilities based on their knowledge and get their own satisfaction when the group results were completed.

It was also found that this strategy is very suitable for use in the Problem Based Learning (PBL) and Project Based Learning (PjBL) learning models. The interview also stated that the process of drawing conclusions together was the most enjoyable part. This makes it easier for students to determine what are the outcomes of the learning that has been done.

Learning outcomes are only felt maximally after the application of this strategy is understood by students. The results of the FGD found that the indicators listed in table 1 were achieved after this strategy was applied more than 4 times. And it was found that the application of this strategy requires intense assistance so that the learning process can be achieved optimally. The process of peer teaching between students in discussion groups is the thing that most shows that the learning process with the OBE approach fosters student team spirit, increases curiosity, improves students' problem-solving abilities in line with research results from [4,11].

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Conclusion

The conclusion of this research is that this strategy can be used in learning on many models, many learning methods and has many learning benefits in terms of cognitive, affective and psychomotor. From this study, it was found that the learning outcomes of mathematics students were able to show the intended achievement in the achievement of the course in accordance with the achievements of its graduates by appropriate to 75%. This study still continues in finding the effectiveness of Rewang Culture-Based learning strategy in several achievement.

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Development of interactive teaching materials based on problem-based learning model to improve students' mathematical reasoning ability

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Abstract. *In this era students are already faced with advances in technology so that students can learn from anywhere with an online learning system. In this research, an interactive teaching material will be developed that can train students' mathematical reasoning abilities. The interactive teaching materials to be developed are in the form of e-book which uses the syntax of Problem Based Learning. This research aims to develop an interactive teaching materials in the form of an e-book based on a valid, practical, and effective Problem Based Learning (PBL) model to improve the mathematical reasoning ability of students majoring in mathematics education at Universitas Negeri Medan. The research instruments used in this study are interactive teaching materials media validation sheets, interactive teaching material validation sheets, and mathematical reasoning ability tests. After all of the instruments were declared valid by experts, field trials were carried out.*

Keywords: interactive teaching materials, PBL learning models, mathematical reasoning skill

Introduction

One form of technological development that is very clear is the development of technology in the field of Education. With technology, the field of Education continues to update the systems, ways, learning media, and teaching and learning processes that occur in the classroom. Many changes in the field of Education as a result of technological developments, these changes are made to improve the quality of education in a better direction. With advances in technology and internet systems that can be used by anyone, the trend of education in this era is online. Students can learn from anywhere, and it is easy for them to access learning videos. For this reason, various skills are needed in managing all the knowledge possessed, one of which is literacy and numeracy skills. Numeracy literacy is closely related to mathematics and is the basic skill to be able to understand and apply mathematics. Numeracy literacy is the knowledge and skill to use various kinds of

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numbers and symbols related to basic mathematics to solve practical problems in everyday life and then analyze information displayed in various forms and interpret the results of the analysis to predict and make decisions [7].

As with numeracy literacy, mathematics cannot be separated from reasoning abilities. [13] found that one of the tendencies that causes a number of students to fail to master the main subjects of mathematics is because they do not use logical reasoning in solving the mathematical questions or problems given. Reasoning ability affects students' mathematical abilities, so this can mean that low reasoning abilities can result in a decrease in students' mathematical abilities. This is in accordance with the results of previous research conducted by Inayah, she obtained results in the form of "reasoning abilities are very necessary to achieve good mathematics learning outcomes, as well as increasing students' reasoning abilities during the learning process is very necessary to achieve success" [12]. Students are declared to have reasoning abilities if they have met the indicators of reasoning.

The results of field observations carried out at the Mathematics Department of Universitas Negeri Medan showed that students had low reasoning abilities. The low level of students' mathematical reasoning abilities can be seen from students who have not been able to present mathematical statements in writing, make conjectures, have difficulty in carrying out mathematical manipulations, and have not been able to draw conclusions from statements. This difficulty occurs because most students have not mastered some of the mathematical concepts they have studied previously. Lack of understanding of students' mathematical concepts results in students lacking in mathematical thinking and resulting in students' low mathematical reasoning abilities.

The learning resources used by lecturers mostly still use printed teaching materials in the form of books. The teaching materials are dominated by text and only contain material and some practice questions. According to Basri, "books that only contain material only allow for the creation of one-way communication which results in a lack of opportunities for students to develop their thinking patterns and students are unable to build their own knowledge to hone their mathematical skills" [1]. The teaching materials used by students cannot train students to develop their reasoning power. This results in the books used not having the expected quality. For this reason, in this study the researchers tried to create interactive teaching materials in the form of e-books which were prepared based on the Problem Based Learning model.

Literature Review

The aim of learning mathematics in this research is that students can understand mathematical concepts and apply these mathematical concepts in solving the problems they face. Apart from that, it is also hoped that students will be able to manipulate and compile evidence for a statement. In this research, to make it easier for students to achieve these learning goals, learning resources are needed that are complete, easy to learn and have an attractive design. The aim of learning mathematics in this research is that students can understand mathematical concepts and apply these mathematical concepts in solving the problems they face. Apart from that, it is also hoped that students will be able to manipulate and compile evidence for a statement. In this research, to make it easier for students to achieve these learning goals, learning resources are needed that are complete, easy to learn and have an attractive design. With complete and interactive learning resources, it is hoped that it can improve students' mathematical reasoning abilities.

Reasoning is an activity or thought process to draw conclusions or make new statements that are based on previous statements and whose truth has been proven [13]. Reasoning is very important in learning mathematics and is a higher-level thinking ability. Reasoning is an activity

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or thought process to draw conclusions or make new statements that are based on previous statements and whose truth has been proven [13]. Reasoning is very important in learning mathematics and is a higher-level thinking ability. With reasoning abilities, students will feel confident that mathematics can be understood, thought about, proven and evaluated.

To improve good reasoning skills, one way is to provide adequate learning resources for students. In this research, researchers tried to develop learning resources in the form of interactive e-books. Interactive teaching materials will be developed using the Flip PDF application as the main application. There are also several supporting applications used to create text, images, animated videos, and sound/music. The application is Ms. Word, Ms. Power Point, Filmora, and Kinemaster. The Flip PDF application will produce a Flipbook, where a Flipbook is a type of book, magazine or slide in electronic form that is displayed as if it were a printed book and can be opened sheet by sheet.

Figure 1. Window flip PDF display

Teaching materials produced by the Flip PDF application can be published in the form of html, exe, zip, screen saver and app extensions. Therefore, the digital media and teaching materials produced can be utilized optimally by users. The output produced by the Flip PDF application can be used online via smartphone, tablet, laptop etc. So, users can access it flexibly without being limited by time and space.

Methodology

This type of research is development research. Research and development or in English called research and development, is a research method used to produce a product. This type of research is development research. Research and development or in English called Research and development, is a research method used to produce a product. In this research, the main focus is to produce a product needed to overcome students' low mathematical reasoning abilities. The product developed is interactive teaching material. The research and development model chosen is the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model The

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research and development model chosen is the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model developed by Dick and Carry. Researchers use the ADDIE model because the ADDIE development model has systematic work stages, the stages can be modified according to the researcher's needs which helps researchers produce a valid product. The procedure is illustrated as follows:

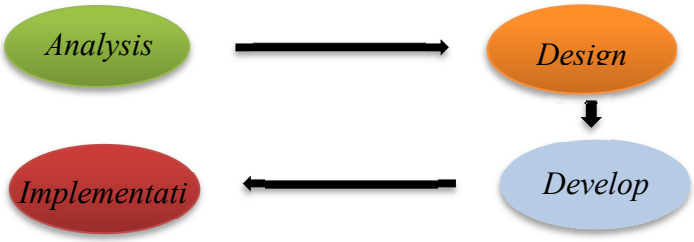

Figure 2: ADDIE development model procedure

1. Analysis
   The analysis stage is the initial stage in development. The analysis stage aims to find out what is needed in developing teaching materials. This analysis was carried out by observing the learning process, interviews with students, diagnostic tests, and distributing questionnaires to students who were research subjects.
2. Design
   In the design stage, researchers planned the design of interactive teaching materials based on the Problem Based Learning model to improve students' mathematical reasoning abilities using the Flip PDF application.
3. Development
   After the design stage is complete, the next stage is development. This stage is the stage of developing interactive teaching materials which researchers will develop using the following steps: (1) develop teaching materials according to the design that has been previously designed, and (2) the developed teaching materials are then validated by material experts and media experts with provide a questionnaire of predetermined criteria and indicators. Validation is carried out until finally the interactive teaching materials developed are declared valid.
4. Implementation
   At the implementation stage, products that have been completed and declared valid and worthy of testing are then tested. The product trial aims to see the practicality and effectiveness of the interactive teaching materials being developed, as well as to determine the feasibility of the products being developed so that final interactive teaching materials can be produced that can improve students' mathematical reasoning abilities.

Data Analysis Technique

Data analysis in this research was carried out to determine the validity, practicality and effectiveness of the interactive teaching materials developed. Data analysis was also carried out to find out how students' mathematical reasoning abilities improved after learning using the interactive teaching materials developed. The analysis used is *quantitative analysis* and *qualitative*

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analysis. For quantitative analysis, test results are analyzed to determine students' mathematical reasoning abilities before and after carrying out learning activities using interactive teaching materials based on the Problem Based Learning model developed. The test results are analyzed based on the test scoring guidelines that have been prepared. The scoring of students' mathematical reasoning ability test results is based on the following indicators:

1. Students are able to present mathematical statements orally, in writing, with pictures.
2. Students are able to make conjectures.
3. Students are able to carry out mathematical manipulations.
4. Students are able to draw conclusions from statements.

Meanwhile, qualitative data is used to determine the feasibility of interactive teaching materials. Qualitative data consists of suggestions, input and criticism on the interactive teaching material assessment sheet by the validator. Then the data was analyzed descriptively qualitatively through the stages of data collection, data reduction and drawing conclusions. After analysis, the data is used as material for revising the interactive teaching materials produced.

Results and Discussion

In media validation in developing interactive teaching materials based on the Problem Based Learning model, there were 4 validators consisting of 3 lecturers and 1 IT expert.

Table 1. Media Expert Validation Assessment Results

Assessment Aspects	Assessment Results					Category
	1	2	3	Total	Average	
Component	4,33	5	4,83	14,16	4,72	Very Valid
Content	4,81	4,9	4,63	14,34	4,78	Very Valid
Interface	4,81	4,9	4,63	14,34	4,78	Very Valid
Interactivity	4	5	4	13	4,33	Very Valid
Technology	5	5	5	15	5	Very Valid
Amount	22,95	24,8	23,09	70,84	23,61	Very Valid

For the analysis of the Practicality and Effectiveness of interactive teaching materials, after field trials were carried out the following results were obtained:

Table 2. Results Of Student Questionnaire Analysis

Assessment Aspects	Item Number	Percentage	Criteria
Display Of Teaching Materials	1(+), 2 (+), 3(+), 18(-), 21(-), 23(-).	93%	Very Positive
Material	4(+), 5(+), 14(-), 25(-).	74%	Positive
Student Interest	6(+), 7(+), 24(-), 17(-).	90%	Very Positive
Language of Images and Videos	8(+), 9(+), 10(+), 26(-), 20(-), 15(-).	88%	Very Positive
Use	11(+), 12(+), 13(+), 22(-), 19(-), 16(-).	84%	Very Positive
Overall Percentage		86%	Very Positive

From the table above, the results of the questionnaire analysis of student responses to interactive

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teaching materials based on the Problem Based Learning model which were developed were 86% obtained by 30 students as respondents to 26 questionnaires. 86% is in the range 81%-100% and is in the very positive category, so based on student responses the interactive teaching materials developed can be categorized as very positive.

In this research, the level of student learning completeness is seen from the students' mathematical reasoning abilities which are known through the results of the final ability test (post-test). The results of student learning completeness are seen individually and classically.

Completeness of Learning Outcomes

Students are said to have completed learning individually if the correct answer results achieved are at least ≤ 70.

Table 3. Percentage of Student Learning Completeness

Information	Value
Average Test Results	75,8
Number of Students Who Have Completed Their Studies	26
The Percentage of Students Who Have Completed Their Studies	87%
Number of Students Who Did Not Complete Their Studies	4
Percentage of Students Who Did Not Complete Their Studies	13%

From the table above it can be seen that of the 30 students there are 26 students who have completed their studies, the percentage is 87% and 4 students who have not completed their studies, or in other words the average student has completed their studies with the average test result obtained being 75.8. A class is said to have completed classical learning if the Classical Completeness Percentage is ≥ 85%. So, it can be concluded that in this research students have completed classical learning.

Achievement of Learning Goals

The effectiveness of the interactive teaching materials developed can be seen from the achievement of learning objectives from the results of mathematical reasoning ability tests. Learning objectives are said to be achieved if 75% of the formulated learning objectives can be achieved by 65% of students, or in other words in this research the learning objectives must be achieved by a minimum of 20 students. Based on the achievement of learning objectives, the number of students who have completed the 9 indicators/learning objectives reaches ≥ 20 students and is greater than 65%.

Results of Student Mathematical Reasoning Ability Assessment

Increasing students' mathematical reasoning abilities using interactive teaching materials developed can be seen from the results of the pre-test and post-test.

Table 4. Average Percentage of Mathematical Reasoning Ability for Each Indicator

Indicators of Mathematical Reasoning Ability	Average Percentage		
	Pre-test	*Post-test*	n-gain
Presenting mathematical statements orally, in writing, with pictures	13,46%	71,83%	58,37%
Make allegations	16,7%	88,3%	71,6%
Performing mathematical manipulations	10.97%	78%	67,03%
Draw conclusions from statements	9,28%	45,98%	36,7%

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Overall, the increase in students' abilities can be seen based on the average increase in each indicator and the gain value. Based on the table, it can be seen that there is an increase in each indicator of mathematical reasoning ability from pre-test to post-test. From the data above, for more details, see diagram below.

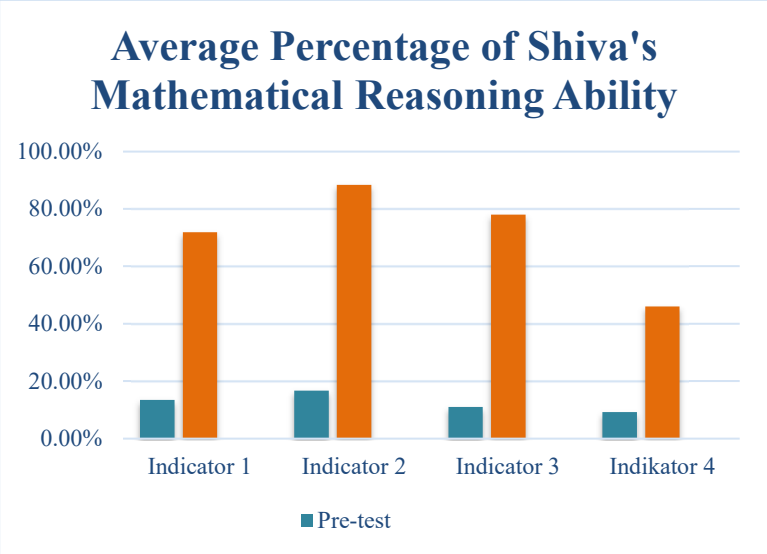

Figure 3. Diagram of the average mathematical reasoning ability of students for each indicator

Furthermore, the increase in students' mathematical reasoning abilities from pre-test to post-test can be seen from the N-gain analysis. Below is a table showing the increase in students' mathematical abilities after learning using interactive teaching materials developed in the form of N-gain in field trials.

Table 5. Improving Mathematical Reasoning Ability in the Form of N-gain

Amount of N-gain	Category	Amount of Student	Percentage	Average
g ≥ 0,70	High	17	57%	0,72
$0{,}30 < g < 0{,}70$	Medium	12	40%	
g ≤ 0,30	Low	1	3%	
Total		**30 Students**	**100%**	

The average N-gain is ≥0.70 and is in the high category, so based on the N-gain value there is an increase in the high category in students' mathematical reasoning abilities. Below is a diagram that illustrates students' mathematical reasoning abilities after learning using interactive teaching materials based on the Problem Based Learning model that was developed.

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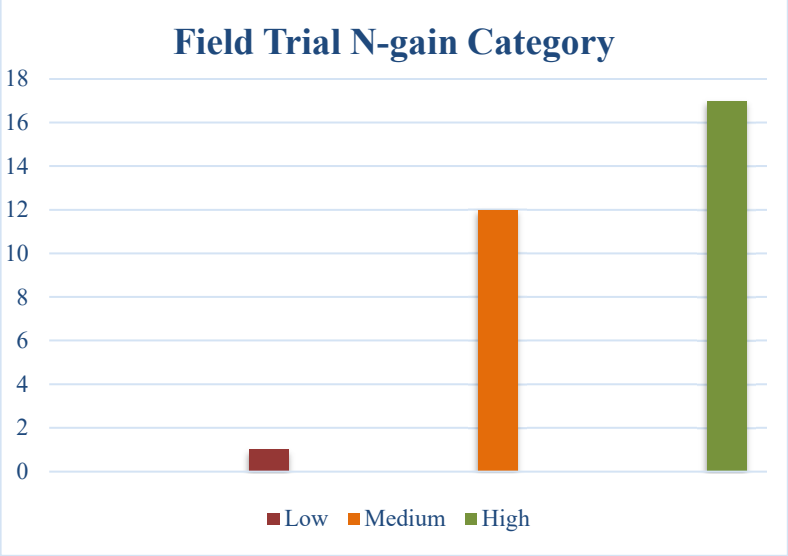

Figure 4. Diagram of Increasing Students' Mathematical Reasoning Ability in N-gain Form

Based on the picture, it can be seen that there are 17 students in the high category, 12 students in the medium category, and 1 student in the low category. The average N-gain obtained is 0.72 which is in the high category. Based on the calculations for the increase in mathematical reasoning abilities discussed above, it can be concluded that students' reasoning abilities have increased from pre-test to post-test in field trials through learning using interactive teaching materials based on the Problem Based Learning model that has been developed. Thus, it can be said that the use of interactive teaching materials based on the Problem Based Learning model has an effect on improving students' mathematical reasoning abilities.

Conclusion

Based on the research results and discussions presented in this research, the conclusions that can be drawn are:

1. Based on the validity aspect, the interactive teaching materials developed have met the validity criteria according to the assessment of media experts and material experts, with an average score of 4.72 and 4.81, where both scores are in the very appropriate category. Based on the practical aspect, the interactive teaching materials developed have met the practicality criteria according to the results of the student response questionnaire of 86%. Based on the effectiveness aspect, the interactive teaching materials developed have been declared effective. This is seen from: a) The completeness of student learning individually and classically. Based on the research results, there were 26 students who completed their studies individually and the percentage was 87%. A class is said to have completed classical learning if the Classical Completion Percentage is ≥85%, and b) achievement of learning objectives, where the 9 indicators/learning objectives formulated are in the range 75% ≤ T <100%, and achieved by ≥ 65% of students. Learning objectives are achieved if 75% of the formulated learning objectives can be achieved by 65% of students, then it can be concluded that in this research the formulated learning objectives have been achieved. Because students' complete learning and learning objectives have been achieved, the interactive teaching materials developed have met the effectiveness aspect.

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2. Increasing the mathematical reasoning abilities of students who are taught using interactive teaching materials based on the Problem Based Learning model that was developed, seen from the results of the pre-test and post-test, where the results have increased. Previously, the average student score on the pre-test was 16.3 and was 76.4 on the post-test. Based on the N-gain analysis, the overall results showed that the increase in students' mathematical reasoning abilities was 0.72 and was in the high category. Based on the criteria table used by researchers, 3% experienced an increase in the low category, 40% experienced an increase in the medium category, and 57% experienced an increase in the high category.

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Development of higher-order thinking skills oriented scaffolding in the course of complex variable functions

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Abstract. Efforts should be made to foster active involvement and promote the development of higher-order thinking skills (HOTS) among students enrolled in the Complex Variable Functions course within the Mathematics Education Study Program at Universitas Negeri Medan. Based on a preliminary investigation, it has been determined that the level of active engagement and HOTS among students remains inadequate. This deficiency can be primarily attributed to the challenges students encounter in grasping and critically evaluating the material conveyed by the instructor. As a result, the discovery of mathematical concepts and principles is suboptimal. This research is a development study of valid, practical, and effective HOTS-oriented scaffolding in the Complex Variable Functions course. The employed research design is the 4-D development design, encompassing the define, design, develop, and disseminate stages. This research was conducted in the mathematics education study program with the research subjects being sixth-semester students currently enrolled in the Complex Variable Functions course. The instruments used in this research include: 1) validation sheets; 2) expert assessment sheets regarding the practicality and effectiveness of the use of the Scaffolding Manual Book; 3) observation sheets on the practicality of using the Scaffolding Manual Book; 4) higher-order thinking skills test for students; 5) observation sheet for learning time allocation; and 6) student response questionnaires. This research begins with front-end analysis, student analysis, task analysis, concept analysis, and the formulation of learning objectives. Subsequently, research instrument design, media selection, format selection, and initial Scaffolding Manual Book design (prototype 1) are carried out. The initial prototype, referred to as Prototype 1, undergoes a process of validation, revision, and classroom trial. Data analysis of expert assessments and classroom trial data is conducted to determine the validity, practicality, and effectiveness of the developed Scaffolding Manual Book, resulting in a final prototype that is valid, practical, and effective in enhancing students' higher-order thinking skills.

Keywords : Development Research, Scaffolding, Higher-Order Thinking Skills, Complex Variable Function

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Introduction

The implementation of constructivist-based learning indicates the characteristics of 21st-century mathematics learning, where students actively play a role in discovering the learning contents, both individually and with the guidance of lecturers. Students are facilitated to explore the learning contents from various sources, enabling them to formulate and solve problems, think analytically, and collaborate to find solutions [1]. Such an approach emphasizes the development of higher-order thinking skills (HOTS), as mandated by the Ministry of Education and Culture of Indonesia in 2018. Based on initial data obtained from a preliminary investigation of the learning process in the Complex Variable Functions (CVF) course in the Mathematics Education Study Program at Universitas Negeri Medan (UNIMED), it is evident that students struggle to abstract the learning contents under discussion. This is evident from the students' responses when questioned by lecturers, which often lead to incorrect answers or answers unrelated to the questions posed. Furthermore, students' active role in discovering concepts and principles within the learning contents falls short of expectations, as students tend to merely accept the material presented by lecturers without asking questions or expressing their ideas. For instance, when proving theorems or properties, students often provide incorrect proofs with non-systematic and axiomatic steps. This has an impact on the failure to achieve the set learning objectives. The initial data aligns with a study conducted by Simanullang et al. in 2022, which revealed suboptimal student engagement and critical thinking skills in lectures. Students struggle with analytical activities such as critiquing, comparing, examining, and grasping the content of the learning material under discussion. As a result, the non-realization of the process of students' discovery of mathematical concepts and principles in the learning process [2].

21st-century mathematics learning must also be integrated with technology [2,3]. The utilization of technology in learning plays a role in representing mathematical objects. The limited ability to represent these objects is influenced by the lack of technology availability in learning [4]. Additionally, technology serves as a bridge between formal and informal mathematical knowledge [5]. Lecturers should seriously consider the patterns of social interaction that occur in technology-dominated mathematics learning [6]. Such learning leads to unpredictable student activities. In other words, social interaction patterns in technology-enhanced mathematics learning must remain focused on the constructive process undertaken by students, with lecturers preventing irrelevant activities resulting from the freedom students have when using technology.

In constructivist-based learning, the role of lecturers is that of facilitator, guide, and provider of scaffolding [7]. Lecturers as providers of scaffolding means that lecturers offer small-scale assistance when all students require such support. This study is conducted to produce a product in the form of scaffolding based on students' thought processes. The concept of scaffolding was initially presented by Wood et al., referring to the assistance provided to students or beginners, allowing them to address problems, perform tasks, or attain objectives that surpass their current abilities [8]. Vygotsky proposed the Zone of Proximal Development (ZPD), which intricately connects with scaffolding. The ZPD delineates the spectrum that spans from the Actual Development Level, characterized by autonomous problem-solving, to the Potential Development Level, which involves problem-solving under the guidance of adults or through collaboration with more capable peers [9]. In other words, scaffolding enables students to experience development within their ZPD. In this study, the development of students' ZPD is related to their mastery of the CVF learning contents based on their higher-order thinking skills.

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Consequently, this study will develop scaffolding oriented toward students' higher-order thinking skills in the CVF course within the Mathematics Education Study Program at UNIMED.

Methodology

This research is a development study using the 4-D design, consisting of four development stages: define, design, develop, and disseminate [10]. The product of this study is scaffolding oriented toward HOTS in the CVF course. The quality criteria for the products in this study refer to three criteria [11], which are valid, practical, and effective. Therefore, the objective of this study is to produce scaffolding oriented toward HOTS in the CVF course.

Table 1. Variables, Instruments, Assessment Criteria, and Research Targets

Variable	Instrument	Assessment Criteria	Target
Validity of HOTS Oriented Scaffolding	a. Validity Sheet of the Scaffolding Manual Book b. Validity Sheet of Students' Worksheet c. Validity Sheet of the Higher-Order Thinking Skills Test	1 ≤ Va < 2 (not valid) 2 ≤ Va < 3 (less valid) 3 ≤ Va < 4 (quite valid) 4 ≤ Va < 5 (valid) Va = 5 (very valid)	Va ≥ Valid
Practicality of the Implementation of HOTS-Oriented Scaffolding	a. Assessment Sheet of the Implementation of Learning (IP)	1 ≤ IP < 2 (very low) 2 ≤ IP < 3 (low) 3 ≤ IP < 4 (medium) 4 ≤ IP < 5 (high) IP = 5 (very high)	IP ≥ High
	b. Observation Sheet of the Implementation of Learning (IO)	1 ≤ IO < 2 (very low) 2 ≤ IO < 3 (low) 3 ≤ IO < 4 (medium) 4 ≤ IO < 5 (high) IO = 5 (very high)	IO ≥ High
Effectiveness of the Implementation of HOTS Oriented Scaffolding	a. Assessment Sheet of the Effectiveness of Learning (IE)	1 ≤ IE < 2 (very low) 2 ≤ IE < 3 (low) 3 ≤ IE < 4 (medium) 4 ≤ IE < 5 (high) IE = 5 (very high)	IE ≥ High
	b. Students' Higher-Order Thinking Skills Test (IA1)	0 ≤ HOTS < 40 (very low) 40 ≤ HOTS < 60 (low) 60 ≤ HOTS < 75 (medium) 75 ≤ HOTS < 90 (high) 90 ≤ HOTS ≤ 100 (very high)	At least 80% of students reach medium HOTS
	c. Time Allocation (IA2)	1 ≤ TA < 2 (very low) 2 ≤ TA < 3 (low) 3 ≤ TA < 4 (medium) 4 ≤ TA < 5 (high) TA = 5 (very high)	TA ≥ High
	d. Questionnaire of Students' Respond (IA3)	Positive or negative response	At least 80% of students respond positively

Adopted from [7]

IP : Intended ↔ Perceived IO : Intended ↔ Operational TA: Time Allocation
IE : Intended ↔ Experiential IA : Intended ↔ Attained
Va : Total Average of Validity Score HOTS : Higher-Order Thinking Skills

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The subjects of this study are sixth-semester students in the academic year 2022-2023, majoring in the Mathematics Education Study Program at UNIMED, who are currently taking the CVF course. The objects in this study are: a) scaffolding oriented toward HOTS in the CVF course; and b) the validity, practicality, and effectiveness of scaffolding oriented toward HOTS developed in the CVF course. Table 1 elaborates in detail the research variables and instruments, assessment criteria, and research targets in this development study.

The cycle of validation, revision, and classroom trial is continuously carried out until scaffolding oriented toward HOTS in the CVF course that is valid, practical, and effective is obtained. The stages and flow of development activities for scaffolding oriented toward HOTS, which are realized in the Scaffolding Manual Book in this study, are presented in the flowchart in Figure 1.

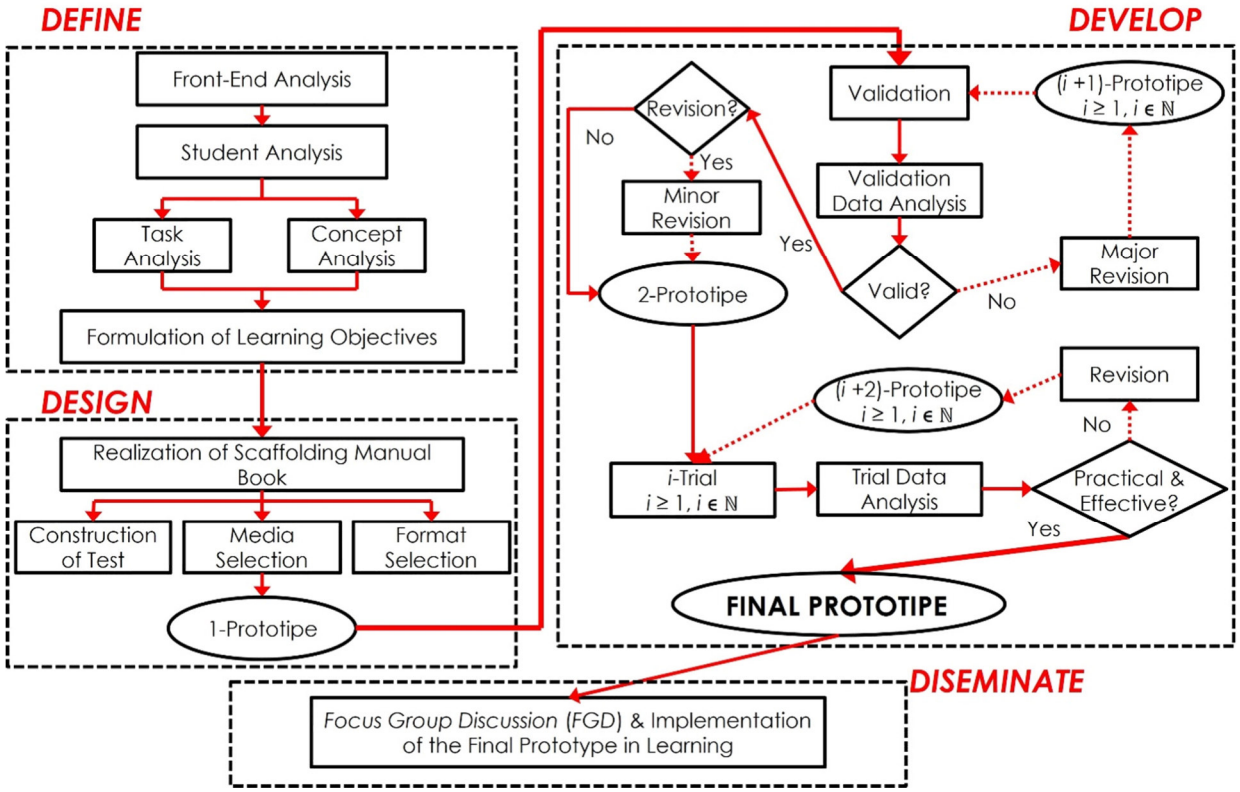

Figure 1. Stages and Flow of HOTS Oriented Scaffolding Development Activities

Results and Discussion

There are three types of HOTS-oriented scaffolding developed in this research, namely guiding questions, relevant simple problems, and illustrations. Guiding questions are a series of systematic and axiomatic questions that help students enhance their critical thinking skills, both in the process of proof and problem-solving. Relevant simple problems are problems that students can generally solve on their own (problems that are at the actual developmental level) that are relevant to the main problem to be solved. Illustrations can be in the form of diagrams, pictures, or animated videos. The research data were obtained based on the consistency of two

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assessments: 1) theoretical assessment by experts based on their mastery of theory and experience, and 2) assessment of classroom trials conducted.

Validity of HOTS-Oriented Scaffolding

The validation process of HOTS-oriented scaffolding is conducted after the design of the HOTS-oriented scaffolding is completed. This process is carried out by three experts who are mathematics education lecturers at UNIMED and have experience in mathematics education research. The objects of assessment in this validation process are The Scaffolding Manual Book, Students' Worksheets, and Higher-Order Thinking Skills Test. This validation process is conducted before the HOTS-oriented scaffolding is implemented in the learning process. The validation data results are presented in a diagram in Figure 2.

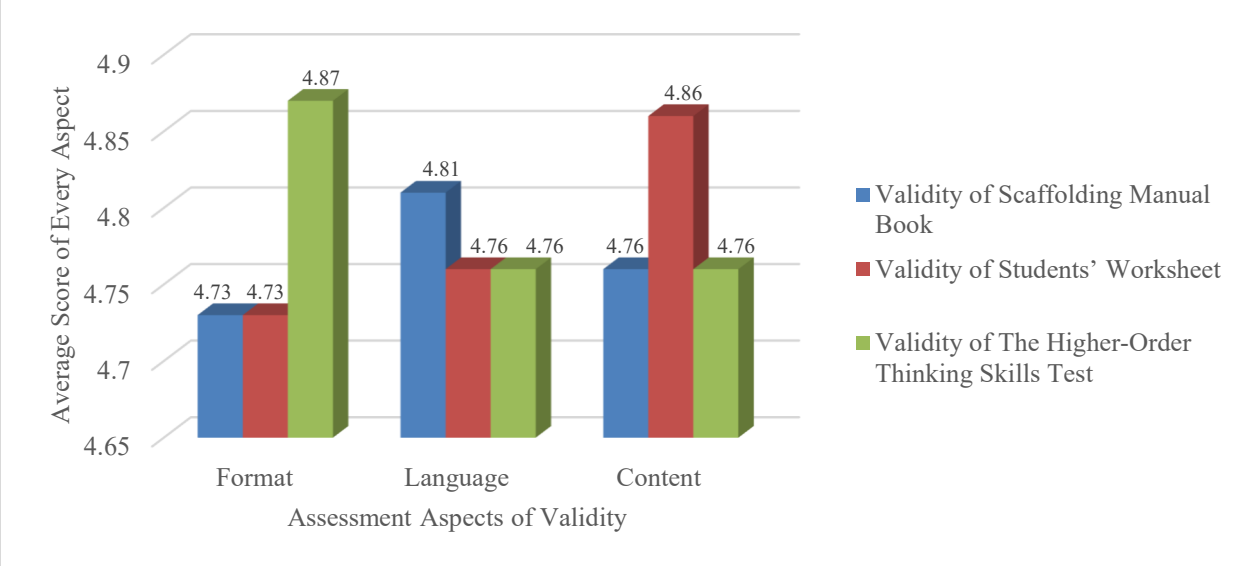

Figure 2. Validity Data of the Scaffolding Manual Book, Students' Worksheet, and Higher-Order Thinking Skills Test

Based on Figure 2, it can be observed that the average validity scores for the Scaffolding Manual Book in terms of format, language, and content are 4.73, 4.81, and 4.76, respectively. Consequently, the total average validity score (Va) for the Scaffolding Manual Book is 4.77. According to the established evaluation criteria (refer to Table 1), it can be concluded that the Scaffolding Manual Book meets the validity criteria. This means that the HOTS-oriented scaffolding developed is considered valid. Similarly, the total average validity scores (Va) for the Students' Worksheets and the Higher-Order Thinking Skills Test are 4.78 and 4.80, respectively. This implies that the Students' Worksheets and the Higher-Order Thinking Skills Test developed also meet the validity criteria.

The Practicality of the Implementation of HOTS-Oriented Scaffolding

The determination of the practicality of implementing HOTS-oriented scaffolding is based on the consistency of two assessment results, namely the assessment by experts before the implementation of HOTS-oriented scaffolding in the classroom (IP) and the assessment by observers during the actual implementation of the teaching in the classroom (IO). The assessment by experts before the implementation of HOTS-oriented scaffolding in the classroom

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is conducted by three experts who, based on their theoretical knowledge and experience, assess the practicality of implementing learning using the developed HOTS-oriented scaffolding theoretically. The assessment by observers during the actual implementation of teaching in the classroom is conducted during the classroom trial of the developed HOTS-oriented scaffolding. This assessment involves observing the teaching process using the developed HOTS-oriented scaffolding. The classroom trial activities are carried out twice in two different classes. The data on the practicality of the developed HOTS-oriented scaffolding is presented in a diagram in Figure 3.

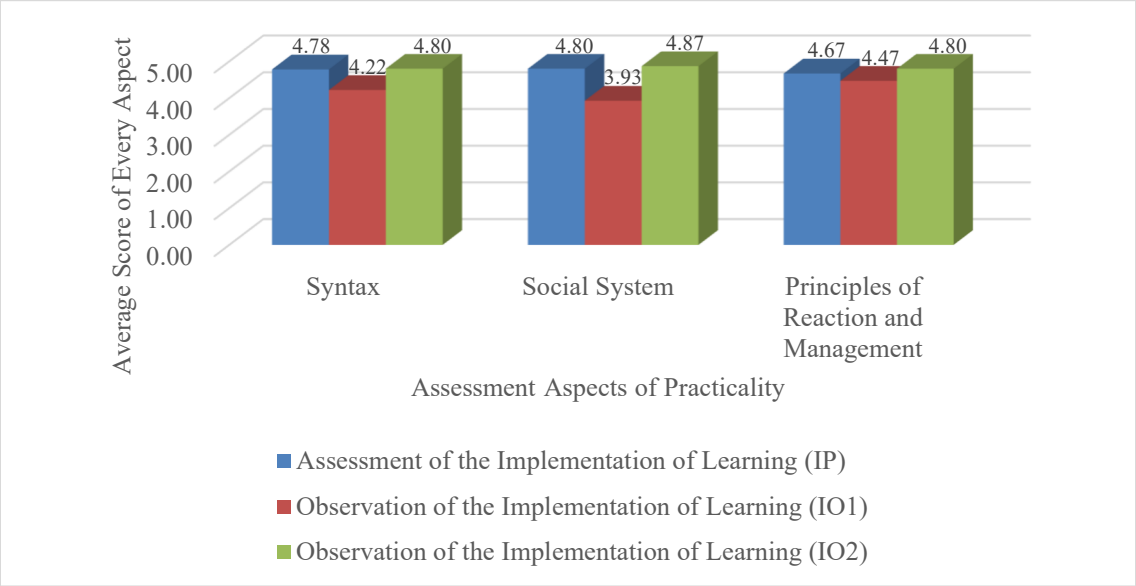

Figure 3. Practicality Data of HOTS-Oriented Scaffolding

Based on Figure 3, it can be observed that the average theoretical practicality scores for the implementation of learning using HOTS-oriented scaffolding, in terms of syntax, social system, and the principle of reaction and management, are 4.78, 4.80, and 4.67, respectively. As a result, the total average theoretical practicality score (IP) for HOTS-oriented scaffolding is 4.75. According to the established evaluation criteria (refer to Table 1), it can be concluded that the practicality of implementing learning using HOTS-oriented scaffolding, as assessed by experts, meets the high criteria. Similarly, the total average practicality scores based on the classroom trials (IO) of HOTS-oriented scaffolding are 4.21 for the first classroom trial and 4.82 for the second classroom trial. This means that the practicality of implementing learning using HOTS-oriented scaffolding, as assessed in the classroom, also meets the high criteria.

Effectiveness of the Implementation of HOTS-Oriented Scaffolding

The determination of the effectiveness of the implementation of HOTS-oriented scaffolding is based on the consistency of two assessment results, namely the assessment by experts before the implementation of HOTS-oriented scaffolding in the classroom (IE) and the achievement of indicators/ aspects of effectiveness set during the classroom trials (IA). The assessment by experts before the implementation of HOTS-oriented scaffolding in the classroom is conducted by three experts based on their theoretical knowledge and experience to determine whether HOTS-oriented scaffolding can be effectively applied in mathematics classrooms. The

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evaluation of the effectiveness of the implementation of HOTS-oriented scaffolding is based on three aspects: students' learning outcomes, time allocation, and support for the achievement of students' responses, with average scores of 4.83, 4.89, and 4.78, respectively. As a result, the total average theoretical effectiveness score (IE) for HOTS-oriented scaffolding is 4.83. According to the established evaluation criteria (see Table 1), it can be concluded that the effectiveness of learning using HOTS-oriented scaffolding, as assessed by experts, meets the high criteria.

The classroom trial activities were conducted twice in two different classes. The data on the effectiveness of the implementation of the developed HOTS-oriented scaffolding is presented in Table 2. According to Table 2, the average post-test score for students' higher-order thinking skills in the first classroom trial is 64.44. Based on the established evaluation criteria (see Table 1), it is concluded that the average post-test score for students' higher-order thinking skills in the first classroom trial falls within the satisfactory criteria. The improvement in students' higher-order thinking skills in the first classroom trial is determined by calculating the average normalized gain, which is 0.21, indicating a low level of improvement. This means that the increase in the average score of students' higher-order thinking skills did not meet the expected level. Similarly, based on the average student response score of 76.50%, it has not yet reached the target of 80%. In contrast, the average score of time allocation over six sessions reached a score of 4.28, which, when referred to the established assessment criteria (see Table 1), has achieved high criteria.

This suggests that the effectiveness of implementing HOTS-oriented scaffolding in the first classroom trial did not meet the predetermined research goal. Therefore, the researchers revised one type of HOTS-oriented scaffolding, specifically the guiding questions, to make them more detailed and systematic for every problem. After the revision process was completed, the researchers conducted a second classroom trial of HOTS-oriented scaffolding. Based on the validity data presented in Figure 2, the practicality data of HOTS-oriented scaffolding in Figure 3, and the effectiveness data presented in Table 2, it is concluded that the developed HOTS-oriented scaffolding has met the criteria for being valid, practical, and effective.

Table 2. Effectiveness Data of HOTS-Oriented Scaffolding in the Classroom Trial

Aspects	**1st Trial**		**2nd Trial**	
Students' Higher-Order Thinking Skills (IA1)	Pre-Test	Post-Test	Pre-Test	Post-Test
	55.03	64.33	55.23	82.00
Time Alloaction (IA2)	4.28		4.50	
Students' Respond (IA3)	76.50%		84.15%	

The findings of this study are in line with those of Simanullang et al.'s research [2], which discovered that the developed scaffolding can improve students' critical thinking skills. The improvement in higher-order thinking skills of students in this study is based on the average normalized gain, which is 0.60, indicating a moderate level of improvement. Furthermore, the implementation of HOTS-oriented scaffolding optimizes the role of students in the learning process, where they can ask critical questions related to the discussed course material, critique information, and construct proofs for theorems and properties accurately.

These findings align with the research by Anghileri, which highlights that the application of scaffolding creates effective interactions in the learning process [12]. The implementation of

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HOTS-oriented scaffolding also facilitates students in interpreting problem contexts, conducting analyses, evaluating problem-solving steps, and explaining related aspects with greater ease (13).

Conclusion

Based on the research findings described earlier, this development study has produced HOTS-oriented scaffolding that is valid, practical, and effective in enhancing students' higher-order thinking skills. The improvement in students' higher-order thinking skills falls within the moderate range of criteria.

Acknowledgments

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Research-Based Learning Model Using Local Wisdom of *Rewang* in Mathematics Education Research

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Abstract. *This research originates from several documentation points highlighting the weak knowledge of research methodology and the lack of experience among students conducting mathematics education research, leading to prolonged student study periods. To address the issue, the research develops a learning model that fosters students' ability to construct their research ideas through a learning strategy by applying the rewang social interaction pattern as Javanese-Sumatran local wisdom. The design research methodology is employed to develop a research-based learning model utilizing the Javanese-Sumatran local wisdom of rewang in the context of mathematics education research. The study involves fifteen mathematics education students from the Mathematics Education program at Universitas Negeri Medan over a six-month period. The results of this research illustrate the journey from the planning stage to the development of a learning model based on the Javanese-Sumatran local wisdom of rewang. This process involves comprehensive exploration, implementation, and analysis steps to make valuable contributions to the field of research methodology learning.*

Keywords: Learning Model, Research-Based Learning, Javanese-Sumatran Local Wisdom, *Rewang*, Research Skills

Introduction

Several research indicates that the prolonged duration of students' studies was almost influenced by students' difficulties in conducting and academically documenting their research [1, 2, 3]. This research training is mandatory for students in the form of writing a thesis [4]. Limited knowledge of research methods, subpar communication quality with supervising professors, limited experience in academic writing, inadequate research methodology guidance from advisors, and the most dominant factor, which is the excessive volume of research methodology content, have been identified as the primary sources of the issues [1, 5]. Therefore, students' abilities in conducting research and academically documenting it are considered to require special attention.

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In the research methods course, the learning process is expected to empower students to master the methods of conducting research and writing scholarly works. Scientific research is a way of constructing a framework for inquiry and truth validation by applying scientific methods supported by tested scientific reasoning, thus requiring research skills [6]. This explanation emphasizes the importance of instructors designing and implementing a research-based learning model. Research methods instructors have the primary task of designing a course that enables students to conduct investigations, make observations, and collect data for research, whether based on field investigations or logical and empirical thinking.

The phenomenon where students encounter difficulties in conducting research is a reality faced by universities [1]. The identification of research problems and questions, problem formulation, literature review, and the selection of relevant research are the primary weaknesses of students in conducting research, directly impacting their difficulties in writing a thesis proposal. Therefore, classroom learning requires an innovative approach that can nurture students' research skills.

Research-Based Learning (RBL), developed at Gadjah Mada University (UGM), Bandung Institute of Technology (ITB), and Gorontalo State University (UNG), has had a positive impact on students' research skills [1]. The implementation of this new paradigm, in the form of the Research-Based Learning model, adapted into the curriculum, demands a change in the teaching and learning behaviors of both teachers and students. This learning model aims to achieve maximum learning outcomes by incorporating the Javanese-Sumatran local wisdom (*rewang*) that aligns with the natural problem-solving approach of Indonesians. The utilization of cultural aspects in education can stimulate higher mental functions [7]. Vygotsky [8] emphasized the importance of incorporating local cultural values in the learning process, relevant to the community in which learning takes place.

The implementation of the Research-Based Learning model based on the Javanese-Sumatran local wisdom (*rewang*) aligns with the idea of decentralized educational innovation, emphasizing the concepts and principles of constructivist learning through a local wisdom approach. The social interaction patterns of *rewang*, which subsequently transform into educational interaction patterns, play a role in regulating students' activities in research-oriented courses. Modifying research-based learning through this cultural approach is necessary to foster students' research skills.

Prahmana and Kusumah [1] identified that the higher education learning process does not adequately support the development of students' scientific writing abilities. Therefore, considering the framework, the development of the Research-Based Learning model based on the Javanese-Sumatran local wisdom to enhance students' research capabilities and scientific writing skills is both necessary and feasible. This development aims to generate innovations and socio-cultural science and technology advancements that can benefit the campus community.

Result and Discussion

This research describes the journey from the planning stage to the development of a learning model based on the Javanese-Sumatran local wisdom. This process involves comprehensive steps of exploration, implementation, and analysis to produce valuable contributions in the field of education.

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Analysis of Research Methods Course Issues

In the analysis phase of the research methods course issues, an evaluation was conducted on the approaches that have been used in teaching research methods in the academic environment. It has been found that there are several potential challenges, such as students' difficulty in comprehending complex concepts, limited interaction in the learning process, or constraints in direct practical application. These issues require attention and improvement to make research methods instruction more effective and beneficial for students.

Potential of Local Wisdom Rewang

Furthermore, a significant potential has been identified in utilizing local wisdom Rewang as an approach in teaching research methods. Rewang is a rich cultural heritage from the Javanese-Sumatran community, encompassing values of wisdom in various aspects of life. This potential includes a culturally based approach, values, and traditions that can be integrated into research methods instruction. The use of local wisdom Rewang has the potential to enhance students' understanding and interest in learning research methods in a more meaningful and contextual way.

Research-Based Learning Model

In developing a research-based learning model, an in-depth analysis of relevant learning theories was conducted. It has been found that an approach that combines the concepts of active, collaborative, and project-based learning is well-suited to the context of teaching research methods. This model allows students to actively engage in the teaching and learning process, collaborate in understanding research concepts, and apply their knowledge in real projects. The integration of local wisdom *Rewang* can also enrich this model with strong cultural values.

Curriculum Analysis

The curriculum used in research methods courses is also analyzed. There are opportunities to integrate elements of local wisdom Rewang into the curriculum. It can be achieved by identifying the points of alignment between *Rewang* values and the research method concepts taught. As a result, research methods instruction can become more contextual, motivate students, and enhance the relevance of learning.

Analysis of Student Characteristics

Analysis of Student Characteristics is also crucial. Students come from diverse cultural backgrounds, have varying levels of understanding, and different interests in research methods. Therefore, the developed learning model should be able to accommodate these differences. By deeply understanding the characteristics of the students, the learning model can be designed in a way that provides an inclusive and relevant learning experience for all students.

Development of Learning Model

To enhance the effectiveness of research methods learning, we have developed a learning model that integrates Javanese-Sumatran local wisdom. This model aims to create a more contextual, meaningful, and inclusive learning experience for students. The learning model is built upon five main components: Syntax, Response Principles, Social System, and Support System.

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Syntax

Syntax refers to the structure and sequence of activities in learning. The syntax was designed to integrate research method concepts with elements of Javanese-Sumatran local wisdom. The learning process begins with the exploration of *Rewang* values relevant to research. Students were introduced to research method concepts through local stories and examples that illustrate the application of local wisdom in the research process. Following that, students engage in group discussions and research projects that combine Rewang principles with research methodologies.

Table 1. Syntax of Research-Based Learning Model Based on Javanese-Sumatran Local Wisdom

No.	Syntax	Activities
1	Cultural Apperception	- Introducing initial competencies and indicators. - Creating a positive perception of *Rewang* culture and knowledge as a social construct. - Explaining the patterns of social and cultural interaction of *Rewang*. - Group determination in problem-solving. - Instilling local wisdom values and the utility of knowledge. - Providing learning motivation.
2	Research Planning through problem-solving representation with *Rewang* social interaction patterns	- Forming *Rewang* groups - Students propose research problems based on facts and construct research designs based on their experiences and abilities. - Requesting students to understand their research problems and conduct literature reviews on their research plans within subgroups and between subgroups within their group using the *Rewang* interaction pattern. - Guiding students to design their research methodologies based on their experiences and abilities, while integrating facts and the influences of their surroundings. - Students allocate time, location, and research subjects.
3	Research Implementation	- Students conduct observations, formulate problems, create hypotheses, and carry out the research experiments that have been designed.
4	Data Processing	- Students process research data to address the formulated problems. - Students draw conclusions from the data processing results.
5	Presentation of Research Findings	- Providing the opportunity for groups to present their research findings in front of the class. - Guiding students to present their work and write about the entire research process until obtaining results in the form of scientific articles. - Students exchange scientific articles among groups and allow other groups to critique/respond to them to receive feedback and evaluation.
6	Dissemination of Research Results (research publication)	- Refining the writing of scientific articles by students after receiving input from lecturers and fellow students during classroom discussions. - Students publish their articles/research findings in scientific journals.

Reaction Principles

The Reaction Principles refer to students' emotional response and motivation to learning. This principle was applied by encouraging students to emotionally connect with the learning material through real-life experiences and cultural values. Students were invited to share their stories and experiences related to the *Rewang* values applied in the research. By stimulating positive emotional responses, students were expected more motivated to learn and apply research concepts.

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Social System

Social System refers to the interaction among students, teachers, and the learning environment. Social interaction becomes a crucial element in learning. Students are encouraged to work in groups with dynamics like the collaborative culture in the daily life of Javanese-Sumatran communities. This collaboration is applied in activities such as discussions, joint analysis, and research project implementation. Teachers facilitate and guides in directing productive social interactions that support the learning process.

Rewangan derives from the word "*rewang*," which means "need assistance" or "help" [9, 10]. Rewang tradition is a culture that involves the active participation of the entire community. Rewang is a moment when people gather, both neighbors and family members, to carry out mutual cooperation activities for the success of an event or wedding ceremony [11]. *Rewang* tradition is not just an event but also a source of inspiration that shapes the values of solidarity in the community of North Sumatra and acts as a driving force in achieving common goals. *Rewang* tradition transcends ethnic boundaries and plays a significant role in the social life of North Sumatra. People are inspired by *Rewang*, and these values form the foundation for their daily lives and achieving shared goals. In the *Rewang* tradition, there are three groups that play a role in problem-solving. These three groups consist of the fathers' group, the youth group, and the mothers' group along with adolescent girls. They interact with each other in the problem-solving process.

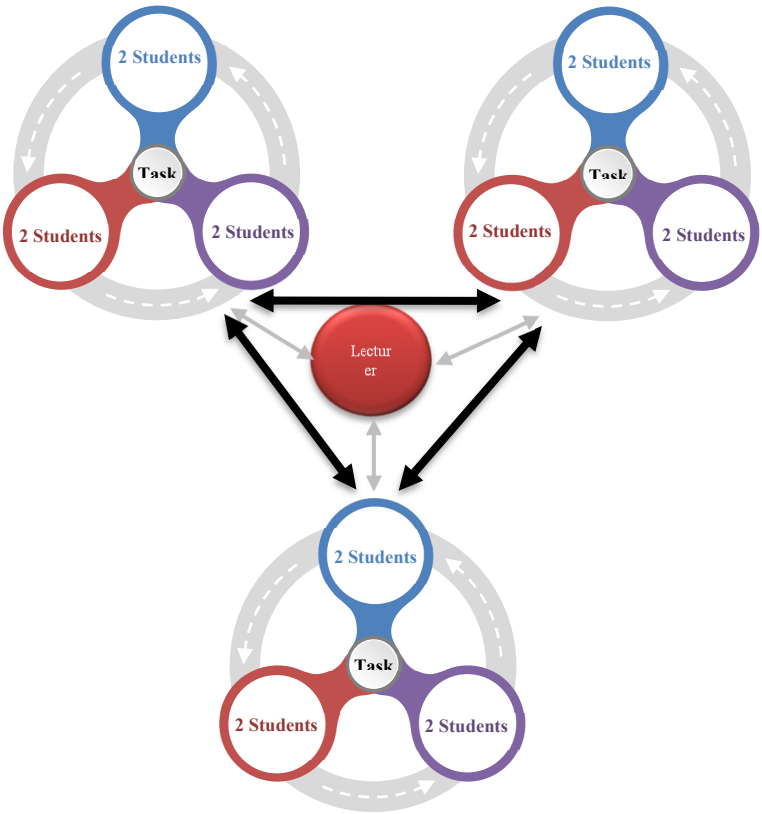

Figure 1. *Rewang* Educational Interaction Pattern in the Learning Process

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The fathers' group is responsible for areas that require specific skills, such as cooking rice, providing water, and constructing shelters. The youth group is tasked with aspects that require physical strength, such as decorations and lifting heavy objects. Meanwhile, the mothers' group along with adolescent girls are responsible for matters related to the kitchen and food preparation. The collaboration of these three groups creates harmony in event execution and problem-solving. The involvement of all parties with different roles reflects the spirit of cooperation and complementarity within the *Rewang* culture. *Rewang* tradition is not just a ceremonial event but also a reflection of the spirit of collaboration and values of solidarity in North Sumatra's society. The collaboration of the three groups in problem-solving illustrates the harmony that occurs in daily life, strengthens social connections, and teaches the importance of cooperation in achieving common goals. The following figure represents the pattern of *Rewang's* educational interaction in learning.

Support System

The Support System encompasses all elements that aid in the smooth flow of learning, such as teaching materials, technology, and other resources. In this model, the support system is organized to support the use of local wisdom and the application of research method concepts. Teaching materials are structured to include practical examples and local stories that illustrate the application of *Rewang* values in the context of research. Technology is also utilized to facilitate collaboration and information sharing among students.

Conclusion

The development of a learning model based on Javanese-Sumatran local wisdom can help enhance students' abilities in conducting research and writing academically. The process of developing this learning model involves thorough exploration, implementation, and analysis to yield valuable contributions in the field of research methods learning. In the context of mathematics education, Javanese-Sumatran local wisdom *Rewang* can be applied as an interaction pattern that assists students in collaborating more effectively in solving mathematics education research.

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Learning style: student learning achievements of analysis real course by online learning

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Abstract. *Online learning has become a common method in the learning process at schools and universities after the Covid-19 pandemic. Synchronous and asynchronous learning is considered a solution to continue the educational process during the pandemic. However, online learning is still unable to meet the needs of students having different learning styles. A person's learning style is generally divided into visual or display, auditory or sound, and kinesthetic or physical. It has been observed that online learning, which focuses more on delivering information visually and orally, is deemed unable to facilitate students with kinesthetic learning styles. To determine the effect of these conditions on learning outcomes, a quantitative approach was utilized with a sample of 77 students who took the "Introduction to Real Analysis" lecture online through video conference, which is synchronous and e-learning or asynchronous. Data were collected using questionnaires and test instruments. Specifically, the questionnaires were used to collect data on the type of students' learning styles, while the test instrument was used to obtain the learning outcomes, which were analyzed quantitatively using statistical tests. It was observed that from the total sample, there were 52 students with visual learning styles, while 9 and 16 had auditory and kinesthetic, respectively. Furthermore, questionnaire and test data were used for statistical analysis and the results showed no difference in the average learning achievement among students with visual, auditory, and kinesthetic learning styles. Therefore, it was concluded that learning style had no significant effect on student learning outcomes in the course taught online during the COVID-19 pandemic.*

***Keyword**:* learning styles, learning outcomes, introduction of real analysis, online learning

Introduction

The COVID-19 pandemic has brought about various changes in the world, such that different fields have been affected, but its origin has not been fully discovered. The world is experiencing a condition that has not been predicted before. For example, everyone must keep a distance from

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other people, known as social distancing, and all activities in public places are limited, including the restriction of movement or lockdown. Consequently, several changes had occurred in the social field, specifically in interaction with other people. One of the areas most affected by this pandemic is education. Education is a field that operates with direct interaction or face-to-face between teachers/lecturers and students in the classroom [1]-[5]. However, this physical classroom meeting was restricted during the Covid-19 pandemic. There was even a time when schools/universities were temporarily closed and learning activities were suspended. The persistence of this condition without any solution is likely to hamper students' knowledge development and negatively affect the country because they are the potential leaders of the nation.

To overcome these obstacles, the Government through the Ministry of Education, Culture, Research, and Technology issued a policy requiring universities and schools to conduct online learning in flexible conditions, since teachers/lecturers can interact with students anywhere and anytime, if there is an internet connection. Moreover, there are some obstacles and shortcomings in this online learning as it is only performed directly or synchronously through face-to-face virtual interaction through video conferencing, such as Zoom, Webex, Google Meet, etc., or indirectly/asynchronously through e-learning, video lectures, etc. These facilities were found to provide knowledgeable information to students through the display of written/visual material and oral/audio explanations. It has also been observed that every learner has different learning styles such as Visual, Auditorial, and Kinesthetic.

Visual learners tend to focus on vision and can properly receive information when it is presented with pictures, diagrams, tables, and attractive displays, such as bright colors, various lines, and shapes. Meanwhile, auditory individuals tend to focus more on hearing and can properly obtain knowledgeable information when it is conveyed orally, and if they are able to hear the explanation audibly i.e., without other voice interference or intermittent explanations. It is important to note that this type does not require an attractive display of information.

The kinesthetic learners are likely to focus more on movement and can obtain knowledgeable information adequately when it is provided with practice. This means that they can easily record the information performed than the information seen or heard.

These various learning styles are often facilitated in face-to-face learning [6] – [9], in which teachers/lecturers provide knowledgeable information by displaying it on the blackboard in a visual form, explanations i.e., auditorial, and practicing or demonstrating in front of the class, which is kinesthetic [10] – [15]. However, it is impossible to optimally perform this during online learning as it only provides a display of material (visual) and its explanation (auditorial) to students. In addition, it is impossible to conduct the practice and demonstration because the learning occurs at different locations, also known as distance learning.

It has also been observed that when the learning material is specifically in abstract forms, such as the "Real Analysis" course, the object in the material is usually in the form of definitions and theorems [16] – [19]. The presentation of this lecture material is usually conducted physically with a display on the blackboard, lecturer's explanation, and demonstration of problem-solving by students in front of the class. However, this is impossible with online learning during the pandemic.

Under these conditions, students with kinesthetic learning styles are not able to absorb information appropriately, thereby causing less optimal learning outcomes. Therefore, an experimental study was conducted to examine the effect of learning style on students' performance in the course taught online during the Covid-19 pandemic.

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Methods

A quantitative approach was utilized in this study [20] and the samples include 77 students offering the Introduction to Real Analysis course. Questionnaires and material tests were used to obtain these data [21]. Specifically, the questionnaire [22] was used to determine student learning styles while tests were employed to obtain quantitative data on learning achievement, consisting of 30 statements in which the responses showed the learning style as reported by the respondent. An essay test instrument was employed for the course material, which consists of 8 questions. The responses to each of these questions were analyzed to obtain students' learning achievement scores. The data obtained from the questionnaire and test instruments were later analyzed inferentially using a one-way ANOVA statistical test and was processed with IBM SPSS 26 software.

Result and Discussion

Result

The data obtained from this study consisted of quantitative tests and questionnaires, which are used to classify students according to their learning styles accessed through the Internet website [22]. Students were asked to fill out a questionnaire on the website, afterward, an analysis result was recorded showing the students' learning style. Also, students were asked to report the results of the completed questionnaire to the lecturer. It was observed that the questionnaire completed contained 30 statements, consisting of 10 questions related to visual learning style, auditory, and kinesthetic, respectively.

The following is a statement on the questionnaire that corresponds to the visual learning style.

When taking an exam, I was able to see the answer in my head such that it is written in a notebook/lesson.

The responses to the statement consisted of three choices, namely:

I always feel like that.

I sometimes feel like that.

I never felt like that.

Choice A, B, and C indicated that students have a 100%, 50%, and 0% probability of visual learning style, respectively.

The auditory learning style is detected through the following statements:

It is easier for me to remember the things I hear than the things I see.

This response consists of three choices, which include:

I always feel like that.

I sometimes feel like that.

I never felt like that.

The choice A, B, and C response showed that students have a 100%, 50%, and 0% probability of auditory learning style, respectively.

The statements employed in identifying kinesthetic learning styles are shown as follows:

I need to participate in an activity related to the material to understand a procedure/material.

This response also consists of three choices, such as:

I always feel like that.

I sometimes feel like that.

I never felt like that.

Choice A, B, and C indicated that students have probabilities of 100%, 50%, and 0%, respectively.

These responses were analyzed for each learning style category and the one having the most dominant is in accordance with students concerned. From the results of the questionnaire

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analysis, the following classification was found in a total sample of 77 people, namely 52, 9, and 16 students with visual, auditory, and kinesthetic learning styles, respectively. For a further statistical test, classification of students' data according to their learning styles is needed. To achieve this, the data obtained from the test instrument in the form of scores/values was later processed and inputted into the IBM SPSS 26 software. The descriptive data of students' learning achievement scores are shown in the chart below:

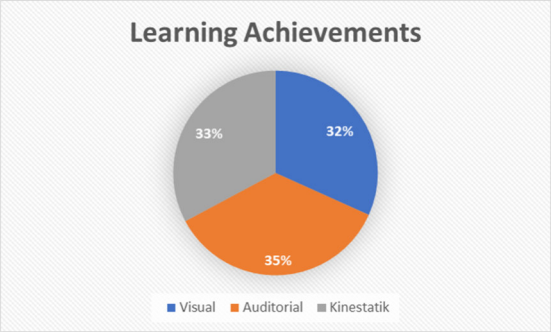

Figure 1. *Chart of student learning achievements based on learning style.*

Figure 1. shows a pie chart of students' mathematics learning outcomes based on their learning styles and it was observed that the performance of those with auditory learning styles is higher when compared to visual and kinesthetic. Meanwhile, the lowest learning achievement was the students with visual learning style. This descriptive data showed that learning styles affected students' learning outcomes during the Covid-19 pandemic, but this data alone is not useful as a basis for a conclusion. Therefore, it must be followed by inferential statistical tests.

This test was performed to determine the effect of learning styles on student learning outcomes using the IBM SPSS 26 software. It was observed that the data had a homogeneous variance with the Levene test, which led to the use of the ANOVA test of which the data about learning styles became the independent variable, while the learning achievement was the dependent.

ANOVA

Hasil Belajar

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	62.141	2	31.071	.073	.930
Within Groups	31537.392	74	426.181		
Total	31599.533	76			

Figure 2. *SPSS Output for One-Way Anova Test.*

Figure 2. shows the results of the ANOVA test with the calculated F-value of 0.073, which was compared with the F-table value of 3.1203. It was discovered that the F-count value of 0.073 is < 3.1203 F-table, indicating that Ho is accepted. It was concluded that there is no difference in the average learning outcomes of Visual, Auditorial, and Kinesthetic learning styles. In addition to the F-count value, statistical inferences were also drawn from the ANOVA test based on the probability value or p-value listed in the Sig column. It was observed that the probability is 0.930 which is > 0.05, indicating that Ho is accepted. This means that there was no difference in the average learning achievement of students with Visual, Auditorial, and Kinesthetic learning

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styles.

After the statistical test, the Post Hoc test was performed to support the ANOVA hypothesis result. The Post Hoc test outputs are as follows:

Multiple Comparisons

Dependent Variable: Hasil Belajar

	(I) Gaya Belajar	(J) Gaya Belajar	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Bonferroni	Visual	Auditorial	-2.81784	7.45314	1.000	-21.0752	15.4395
		Kinestatik	-.10517	5.90187	1.000	-14.5625	14.3522
	Auditorial	Visual	2.81784	7.45314	1.000	-15.4395	21.0752
		Kinestatik	2.71267	8.60173	1.000	-18.3583	23.7836
	Kinestatik	Visual	.10517	5.90187	1.000	-14.3522	14.5625
		Auditorial	-2.71267	8.60173	1.000	-23.7836	18.3583

Figure 3. *SPSS output for Bonferroni Post Hoc test.*

It was observed from **Figure 3.** that the mean visual learning style is not significantly different from the Kinesthetic. The mean auditorial learning style is also not significantly different from the kinesthetic, and kinesthetic is not significantly different from the visual and auditorial. In other words, there is no significant difference in the mean of these three learning styles, which led to the conclusion that learning style does not affect learning achievement.

Discussion

The inferential statistical analysis result of students' learning achievement data and learning styles showed that there was no significant difference in the learning outcomes of students with visual, auditory, and kinesthetic learning styles. Also, the Post Hoc follow-up test showed that the learning style had no significant effect on learning achievement in online lectures during the Covid-19 pandemic. These results were also consistent with several other studies [23], [24], indicating that there is no significant correlation between learning styles and learning outcomes. One of the factors that led to these results is that tertiary/university learning is andragogy, also known as adult learning. The insignificant difference in the average learning achievement of the three learning styles is probably due to the nature of the “Introduction to Real Analysis” course which focused more on the material, which is abstract but without practical. This course requires students' higher-order thinking skills (HOTS), thereby causing them to focus more on honing their thinking skills rather than those requiring physical movement and demonstration.

It is important to note that the results obtained are quite different from other studies conducted outside of the Covid-19 pandemic [25]-[27] as it was found that learning styles have a significant effect on student learning outcomes. In [27], the learning style is positively correlated with student achievement and the best learning style was the visual learning style. Meanwhile, [25], [26] discovered that the kinesthetic learning style has the highest positive correlation to learning achievement.

It has been observed that the differences in these results are often caused by several factors. One of which is the facilities and infrastructure used during the learning period outside of the Covid-19 pandemic. At that time, various learning facilities such as laboratories, practicum places, and public libraries were easily accessible to students, which helped them to freely study according to their learning style. However, during the pandemic, learning is conducted through online learning media, which caused the campus facilities to be inaccessible to students. When treated equally, it turns out that learning style does not affect student learning achievement.

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Conclusion

The results of the data analysis using the one-way ANOVA statistical test showed that there was no significant difference in average learning outcomes among students with visual, auditory, and kinesthetic learning styles. Therefore, it is concluded that learning styles had no effect on student learning outcomes in the "Real Analysis" course that was conducted by online learning.

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The Development of Mathematics Discourse-Based Learning to Improve Teacher Students' Procedural and Conceptual Understanding of Multivariable Calculus

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Abstract. *This study investigates the efficacy of a discourse-based learning approach in enhancing the procedural and conceptual understanding of multivariable calculus among future mathematics teachers. Utilizing a mixed-methods design, the research examined the impact of this innovative teaching approach on students' understanding, attitudes, and confidence. Results indicated significant improvements in procedural and conceptual understanding among the experimental group. Students also reported positive shifts in their attitudes toward multivariable calculus and increased confidence in teaching this subject. Despite initial challenges with this new learning approach, the discourse-based learning method offered opportunities for deeper understanding and active participation. The findings highlight the potential of discourse-based learning in mathematics education and suggest areas for further exploration and refinement. The study underscores the need for future research to assess the long-term effects, applicability to other mathematical domains, and strategies for effective implementation.*

Keyword: Discourse-based learning, Procedural understanding, Conceptual understanding, Mathematics education, Innovative teaching.

Introduction

Multivariable calculus is an advanced branch of mathematics that extends the concepts of calculus to functions of multiple variables. This field explores the behavior and rate at which these functions change and finds practical applications in various disciplines, including physics, engineering, economics, and computer science [1]. Understanding multivariable calculus requires procedural knowledge—knowing how to perform operations such as differentiation and integration—and conceptual understanding—grasping why these operations work and their implications [2]. Given its complexity and abstract nature, teaching multivariable calculus poses unique challenges for educators.

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In mathematics education, two types of knowledge are widely recognized as fundamental: procedural and conceptual. Procedural knowledge refers to the ability to execute action sequences to solve problems, such as using formulas or algorithms. Conversely, conceptual knowledge involves understanding why procedures work and the principles underlying mathematical concepts [2]. Both types of understanding are crucial for learning mathematics effectively. Procedural knowledge allows students to perform computations accurately and efficiently. However, without a solid conceptual understanding, students may struggle to apply these procedures in novel contexts or solve non-routine problems [3,4]. Conceptual understanding also supports the development of procedural fluency. Research has shown that when students understand underlying mathematical concepts, they are better able to learn and remember related procedures [5]. Furthermore, a strong foundation in procedural and conceptual knowledge contributes to flexible problem-solving skills—an ability highly valued in advanced mathematics such as multivariable calculus. Therefore, fostering both understanding types is critical to effective teaching strategies in mathematics education.

Teaching multivariable calculus presents numerous challenges. First, the subject matter itself is complex and abstract. Concepts such as partial differentiation, multiple integration, and vector fields require students to visualize and manipulate objects in three dimensions or more [6]. This can be difficult for many students who are accustomed to the two-dimensional thinking required in single-variable calculus. Secondly, teaching multivariable calculus requires a balance between procedural and conceptual understanding. While it's important for students to learn how to perform operations like differentiation and integration (procedural knowledge), they must also understand why these operations work (conceptual knowledge) [7]. Striking this balance can be challenging. Finally, textbooks and traditional lecture methods often focus on procedures at the expense of concepts [8]. This approach may lead to rote learning rather than deep understanding. Students may be able to perform calculations correctly without truly understanding the underlying concepts or being able to apply their knowledge in novel situations. In summary, effective instruction in multivariable calculus requires innovative teaching strategies that address these challenges.

A significant challenge in mathematics education, particularly in advanced subjects like multivariable calculus, is the insufficient understanding among teacher students in both procedural and conceptual aspects. Procedurally, teacher students may struggle with executing mathematical operations correctly and consistently. For instance, they may have difficulty performing operations such as partial differentiation or setting up and solving multiple integrals [9]. This lack of procedural fluency can lead to errors and misconceptions that hinder their ability to solve complex problems. Conceptually, teacher students often grapple with understanding the underlying principles of multivariable calculus. They might be able to perform calculations without truly comprehending why certain procedures work or how different concepts are interconnected [10,11]. This lack of conceptual understanding can limit their ability to apply mathematical knowledge in novel situations or explain these concepts effectively to their future students. Moreover, research suggests that many prospective teachers themselves possess a fragmented understanding of mathematics due to their own educational experiences [12,13]. This situation is problematic as teachers' mathematical knowledge significantly influences the quality of student learning outcomes. Hence, there is an urgent need for effective instructional strategies that can enhance both procedural and conceptual understanding among teacher students in multivariable calculus.

The main objective of this study is to develop and evaluate a mathematics discourse-based learning approach aimed at improving teacher students' procedural and conceptual understanding of multivariable calculus. Specifically, the study aims to: (1) design a discourse-based learning

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framework that encourages active engagement, critical thinking, and deep understanding of multivariable calculus concepts, (2) implement this discourse-based learning approach in a sample group of teacher students taking multivariable calculus courses, (3) evaluate the effectiveness of this approach by comparing pre- and post-intervention measures of students' procedural fluency and conceptual understanding, (4) explore how participation in mathematical discourse influences teacher students' attitudes towards multivariable calculus and their confidence in teaching this subject in future, and (5) provide insights into how discourse-based learning can be integrated into mathematics education more broadly to improve student outcomes. Through these objectives, the study hopes to contribute to pedagogical strategies in higher-level mathematics education, specifically targeting the preparation of future teachers who will be responsible for imparting these complex mathematical concepts to their own students.

Discourse-based learning

Discourse-based learning is grounded in the socio-cultural theory of learning, which emphasizes that learning occurs through social interaction and language use [14]. In this perspective, knowledge is constructed through dialogue and collaboration rather than merely transmitted from teacher to student. The work of Vygotsky is particularly relevant. His concept of the "zone of proximal development" suggests that learners can achieve more with guidance and peer collaboration than they can independently [15]. Discourse-based learning facilitates this kind of guided interaction. Bakhtin's theories also provide a useful framework for understanding discourse-based learning. Bakhtin proposed the idea of dialogism-the interplay between multiple voices or perspectives in a dialogue [16]. In a discourse-based classroom, students' individual understandings are shaped and refined through engagement with diverse perspectives. Furthermore, Mercer's classification of talk as disputation, cumulative, or exploratory can be useful in analyzing the quality of mathematical discourse [17]. Exploratory talk, where students build on each other's ideas and challenge each other's reasoning critically yet constructively, is particularly conducive to deep mathematical understanding. In mathematics education specifically, Sfard's cognitive framework provides a theoretical basis for studying mathematical thinking as a form of communication [18]. This perspective emphasizes that mathematical concepts are developed and understood through discursive activities.

Effectiveness of discourse-based learning in mathematics learning

Previous research provides substantial evidence for the effectiveness of discourse-based learning in mathematics. In a study by [19], students who participated in mathematical discussions demonstrated higher levels of understanding and achievement than those who did not. Similarly, [20] found that students who engaged in exploratory talk during mathematics lessons developed better problem-solving skills than their peers. These findings are consistent with the work of [21], who reported that students' mathematical reasoning improved significantly when they were encouraged to articulate their thinking through discourse. Furthermore, [22] concluded that classroom discourse can positively impact students' conceptual understanding across different areas of mathematics, including complex subjects like calculus. These studies suggest integrating discourse into mathematics instruction can enhance procedural fluency and conceptual experience.

Current methods used to teach multivariable calculus and their limitations

Traditional approaches to teaching multivariable calculus often rely heavily on lecture-based instruction and rote memorization of procedures [23]. While these methods can effectively teach specific mathematical skills, they may not foster deep conceptual understanding or critical thinking

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[24]. For instance, students may learn how to compute multiple integrals without understanding the geometric interpretation of this operation [25,26]. Furthermore, traditional instruction often does not provide opportunities for students to engage in mathematical discourse or collaborative problem-solving activities that could enhance their understanding [11]. As a result, many students struggle with multivariable calculus and perceive it as a complex subject [27]. These limitations suggest the need for innovative teaching strategies that promote both procedural fluency and conceptual understanding in multivariable calculus.

The role of procedural and conceptual understanding in mathematics education

Procedural and conceptual understandings are both critical components of mathematics education. Procedural understanding refers to how to execute procedures or algorithms, such as computing an integral in calculus [28]. On the other hand, conceptual understanding involves comprehending mathematical concepts, operations, and relations - it's about knowing why a particular mathematical statement is true or where a mathematical rule comes from [29]. Research suggests that these two types of knowledge are interrelated and mutually supportive. For example, [30] found that students with strong procedural knowledge can leverage it to develop their conceptual understanding and vice versa. Moreover, students who possess both types of knowledge are more likely to transfer what they have learned to new situations [2]. In multivariable calculus teaching specifically, fostering both procedural fluency and conceptual comprehension is crucial for enabling students to carry out complex calculations and understand the underlying mathematical principles [6,31].

Method

An explanatory sequential design [32] was used. In the first phase of this design, the discourse-based learning approach was implemented in a multivariable calculus course, and quantitative data on students' procedural fluency and conceptual understanding were collected. This was done using pre- and post-tests designed to measure these constructs. In the second phase, qualitative data were collected to help explain or build upon the quantitative results. Interviews and focus groups were conducted with students to explore their attitudes toward multivariable calculus and their experiences with discourse-based learning. Classroom interactions [33] were also observed to identify challenges and opportunities associated with implementing this approach. Integrating quantitative and qualitative data allowed for a comprehensive understanding of how discourse-based learning impacts teacher students' understanding of multivariable calculus.

Participants

The study population consisted of third-year students from the Mathematics Education Study Program at Medan State University, Indonesia. The students were divided into seven classes, each with a balanced composition of male and female students. To meet the requirements of the quasi-experimental design, two classes, PSPM22B and PSPM22F, were selected through a cluster random sampling process. The class PSPM22B, with 32 students (9 males, 23 females), was randomly assigned as the experimental group. This group was exposed to the discourse-based learning approach. Conversely, PSPM22F, with 35 students (10 males, 25 females), was assigned as the control group and received the traditional instruction method. This pretest-posttest nonequivalent group design allowed for a direct comparison of the effects of the intervention while preserving the natural classroom environment.

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Procedure

The implementation of the discourse-based learning approach was carried out in the experimental group class, PSPM22B. The approach was integrated into the multivariable calculus course, replacing the traditional teaching methods for a designated period. In the discourse-based learning sessions, students were encouraged to participate in mathematical discussions actively, explaining their thought processes, questioning each other, and collaboratively solving problems. This method fostered a deeper procedural and conceptual understanding of multivariable calculus. The teacher facilitated these discussions, guiding students to make connections between different concepts and procedures. Periodically, the teacher would introduce new concepts or problems to stimulate further discussion. To evaluate the effectiveness of this teaching approach, pre- and post-tests were administered to measure students' procedural fluency and conceptual understanding. The same tests were given to the control group, PSPM22F, who received traditional instruction. This procedure allowed for comparing learning outcomes between the discourse-based and traditional teaching approaches.

Instruments for data collection

A combination of quantitative and qualitative instruments was used to collect data on the effectiveness of the discourse-based learning approach. The quantitative data was collected using pre- and post-tests to measure students' procedural fluency and conceptual understanding of multivariable calculus. The tests comprised questions that required students to perform calculations and explain mathematical concepts, allowing for an assessment of both their procedural skills and conceptual understanding. These tests were administered to the experimental and control groups before and after the intervention to measure learning gains attributable to the discourse-based learning approach. In the study's second phase, qualitative data was collected to provide an in-depth understanding of students' experiences with discourse-based learning. Semi-structured interviews and focus group discussions were conducted to explore students' attitudes toward multivariable calculus and their perceptions of the discourse-based learning approach. The interview and discussion guides were developed with open-ended questions to elicit detailed responses. Additionally, classroom observations were carried out, and field notes were taken to document the classroom interactions, particularly the challenges and opportunities associated with implementing discourse-based learning. These multiple instruments provided a comprehensive dataset for analyzing the impact of the discourse-based learning approach on students' understanding of multivariable calculus.

Results

This section presents the results obtained from the implementation of the discourse-based learning approach, providing a detailed analysis of its impact on the procedural and conceptual understanding of multivariable calculus among teacher students.

Students' understanding before and after intervention

Before the intervention, both procedural and conceptual understanding of multivariable calculus was assessed using pre-tests. The experimental group (PSPM22B) demonstrated an average procedural understanding score of 64.3 out of 100 (SD = 9.2), indicating a moderate level of understanding with potential for enhancement. In contrast, the control group (PSPM22F) exhibited a slightly higher average score of 66.1 (SD = 8.9). An independent samples *t*-test showed no significant difference between the groups ($t(65) = 0.96$, $p > 0.05$), verifying their comparability

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for further stages of the study. Regarding conceptual understanding, the experimental group (PSPM22B) achieved an average pre-test score of 63.9 out of 100 (SD = 8.7), suggesting room for improvement. However, the control group (PSPM22F) scored slightly higher, with an average of 64.7 (SD = 8.2). An independent samples *t*-test confirmed no significant difference between the two groups ($t(65) = 0.52$, $p > 0.05$). These scores serve as a baseline for assessing the intervention's impact on procedural and conceptual understanding.

After implementing the discourse-based learning approach, both procedural and conceptual understanding was re-assessed through post-tests. The experimental group (PSPM22B) demonstrated a significant improvement in procedural understanding, with an average post-test score of 80.6 out of 100 (SD = 8.1). This represented a substantial increase from the pre-test average. The control group (PSPM22F) continued with traditional instruction and showed a marginal improvement, with an average post-test score of 68.7 (SD = 9.3). A paired *t*-test showed a significant increase in scores for the experimental group ($t(31) = –10.2$, $p < 0.001$), while the control group showed no significant difference ($t(34) = –1.4$, $p > 0.05$). Furthermore, an independent samples *t*-test indicated a significant difference between the groups' post-test scores ($t(65) = 5.8$, $p < 0.001$), with the experimental group scoring higher. Regarding conceptual understanding, the experimental group (PSPM22B) showed a substantial improvement, with an average post-test score of 78.4 (SD = 7.3). However, the control group (PSPM22F) showed a minor increase, with an average post-test score of 67.2 (SD = 9.0). A paired *t*-test indicated a significant increase in scores for the experimental group ($t(31) = –9.7$, $p < 0.001$) but no significant difference for the control group ($t(34) = –0.9$, $p > 0.05$). An independent samples *t*-test revealed a significant difference between the groups' post-test scores ($t(65) = 6.1$, $p < 0.001$), with the experimental group scoring higher.

Students' attitudes and experiences

The qualitative data, collected through interviews and focus group discussions, provided in-depth insights into students' attitudes toward multivariable calculus and their experiences with the discourse-based learning approach. After the intervention, most students in the experimental group (PSPM22B) expressed positive attitudes toward multivariable calculus. They reported that the discourse-based learning approach made the subject more engaging and less intimidating. One student stated, "*Before, I used to dread multivariable calculus, but now I enjoy the discussions and problem-solving sessions; it's like a puzzle that we solve together*." In terms of their perceptions of the discourse-based learning approach, students highlighted the collaborative nature of the learning process. They appreciated the opportunity to discuss and debate different problem-solving strategies, which enriched their understanding of the subject. For instance, one student shared, "*Through the discussions, I could see different ways to solve a problem, which helped me understand the concepts better*."

Additionally, students expressed increased confidence in their ability to teach multivariable calculus in the future. They attributed this newfound confidence to their improved understanding of the subject and the pedagogical skills they gained from the discourse-based learning sessions. A student remarked, "*Seeing how our teacher facilitated the discussions gave me ideas on how to teach this subject in the future*." However, some challenges were also reported. Some students initially found it difficult to articulate their thought processes during the discussions, while others hesitated to question their peers' solutions.

Nevertheless, students reported becoming more comfortable with the discourse-based learning approach as the sessions progressed. The focus group discussions corroborated these findings.

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Students expressed enthusiasm for the discourse-based approach, noting that it encouraged active participation and fostered a deeper understanding of multivariable calculus. They also acknowledged that while the method was initially challenging, they could adapt with time and felt that the benefits outweighed the initial difficulties. This qualitative data suggests that the discourse-based learning approach was well-received by students and positively impacted their attitudes toward multivariable calculus and their confidence in teaching the subject. Despite some initial challenges, students found the approach beneficial for their learning.

The classroom observations and field notes provided valuable insights into implementing the discourse-based learning approach in the multivariable calculus course. The interactive nature of the approach was evident, with students actively engaging in mathematical discussions and problem-solving activities. The teacher played a pivotal role in facilitating these dialogues, guiding students to make connections between different concepts and procedures. A few key opportunities and benefits of the discourse-based learning approach were identified. One of the most notable was the shift in students' engagement levels. They actively participated in mathematical discourse, showed enthusiasm for solving problems, and were willing to question and challenge each other's ideas. This active participation fostered a deeper understanding of complex multivariable calculus concepts.

Additionally, the approach seemed to enhance students' confidence in their mathematical abilities, as evidenced by their active participation and increasing comfort in sharing and justifying their problem-solving strategies. However, the implementation of the discourse-based learning approach was not without challenges. Some students initially struggled to articulate their thought processes during the discussions. They also hesitated to question their peers' solutions, possibly due to a lack of confidence or fear of confrontation. It was noted that these issues diminished over time as students became more accustomed to the discourse-based approach.

Furthermore, the teacher faced challenges in managing the classroom dynamics. Ensuring that all students participated equally in the discussions required continuous attention. Additionally, guiding the discussions without dominating them required a delicate balance. Overall, the classroom observations and field notes suggest that, despite the initial challenges, the discourse-based learning approach provided a dynamic and engaging learning environment. It fostered active learning and a deep understanding of multivariable calculus, indicating its potential as a practical teaching approach.

Discussion

The results of this study suggest that the discourse-based learning approach significantly impacts teacher students' procedural and conceptual understanding of multivariable calculus. The experimental group (PSPM22B), which underwent the discourse-based learning approach, showed a substantial improvement in both their procedural and conceptual understanding compared to the control group (PSPM22F), as evidenced by the significant increase in post-test scores. In addition to the quantitative findings, qualitative data also supported the effectiveness of the discourse-based learning approach. Students in the experimental group expressed positive attitudes toward multivariable calculus and perceived the learning approach as beneficial. They reported improved confidence in their ability to understand and teach multivariable calculus, attributing this to their enhanced understanding and the pedagogical skills they gained from the discourse-based learning sessions. While some students initially found it challenging to articulate their thought processes and question their peers' solutions, these issues diminished as they became more accustomed to the approach. Classroom observations and field notes further illuminated the discourse-based

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learning approach's implementation. Despite initial articulation and peer questioning challenges, the students adapted to the approach over time. The active participation and engagement observed in the classroom indicated the approach's success in fostering a deeper understanding of multivariable calculus. The teacher's role as a facilitator in guiding the discussions and making connections between different concepts and procedures was pivotal to the success of this teaching approach. However, the study highlighted the challenges of managing classroom dynamics and ensuring equal participation. These challenges suggest a need for further training for teachers in implementing discourse-based learning effectively. Overall, these findings underscore the potential of the discourse-based learning approach as an effective teaching strategy in mathematics education, particularly for complex subjects like multivariable calculus. These results are promising for improving teacher students' procedural and conceptual understanding of multivariable calculus and their confidence in teaching this subject. However, further research is needed to explore the long-term effects of this approach and its applicability in different educational contexts.

The findings of this study align with the broader body of research supporting the efficacy of discourse-based learning in mathematics education. Many studies have underscored the value of mathematical discourse in enhancing students' conceptual understanding (e.g., [34,35,36,37]). This study's significant improvements in procedural and conceptual understanding of multivariable calculus provide additional evidence for these assertions. The positive attitudes and increased confidence expressed by the students in the experimental group resonate with the findings of other researchers who have investigated the effects of discourse-based learning. For instance, [38] have documented that students who engage in discourse-based mathematics instruction show increased interest and confidence in mathematics. This study extends this finding to the context of multivariable calculus and future mathematics teachers.

However, the challenges identified in this study, such as the initial difficulty in articulating thought processes and questioning peers' solutions, also echo issues raised in the literature. For example, [39] have noted that students may need time and support to learn how to engage productively in mathematical discourse. The classroom dynamics challenges that emerged in this study suggest that further research is required to develop effective strategies for managing these dynamics. As observed in this study, the teacher's role as a facilitator in the discourse-based learning approach is consistent with the theoretical framework of sociocultural theories of learning [14]. These theories emphasize the importance of social interactions in education and view the teacher as a guide who scaffolds students' knowledge within their zone of proximal development. Overall, the findings of this study contribute to the growing body of evidence supporting the effectiveness of discourse-based learning in mathematics education. They also highlight the need for further research to address the challenges of implementing this approach and explore its long-term effects and applicability in different educational contexts.

Conclusion

The present study aimed to investigate the design, implementation, and outcomes of a discourse-based learning approach in enhancing teacher students' procedural and conceptual understanding of multivariable calculus. Five primary research questions guided the study, focusing on the design of the approach, its impact on students' understanding, the effect on students' attitudes and confidence, and the associated challenges and opportunities. The results indicated that the discourse-based learning approach significantly improved the experimental group's procedural and conceptual understanding of multivariable calculus, as evidenced by the

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significant increase in post-test scores compared to the control group. This addresses the first three research questions, suggesting that a discourse-based learning approach can be effectively designed and implemented to foster a deeper understanding of multivariable calculus. Regarding the fourth research question, qualitative data revealed that the discourse-based learning approach positively influenced students' attitudes towards multivariable calculus and their confidence in teaching this subject. Despite initial challenges in articulating their thoughts and questioning peers, students reported increased engagement and enjoyment in learning multivariable calculus. They also expressed greater confidence in their ability to teach this complex subject in the future. The study identified several challenges and opportunities associated with the discourse-based learning approach, addressing the fifth research question. While some students initially struggled with the new learning approach, these issues diminished over time. Conversely, the approach presented opportunities for active learning, deeper understanding, and increased confidence among students.

The findings of this study have crucial implications for teaching practice. They highlight the potential of discourse-based learning as an effective instructional approach, particularly for complex subjects like multivariable calculus. Teachers could consider integrating discourse-based learning into their instruction to foster deeper conceptual understanding and procedural fluency among students. Additionally, the study underscores the importance of providing support to students in the early stages of implementing discourse-based learning, such as scaffolding their participation in mathematical discourse. This could involve explicit instruction in articulating mathematical thinking and questioning strategies. Finally, the findings suggest a need for teacher training in managing classroom dynamics and facilitating mathematical discourse, to maximize the benefits of the discourse-based learning approach.

While this study offers valuable insights into the implementation and outcomes of a discourse-based learning approach in multivariable calculus instruction, it has several limitations that should be acknowledged. First, the study was conducted with a relatively small sample size from a single university, which may limit the generalizability of the findings. Further studies incorporating larger and more diverse samples across different educational institutions could provide a more comprehensive understanding of the approach's effectiveness. Second, the study relied on self-reported data from students to gauge their attitudes toward multivariable calculus and their experiences with the discourse-based learning approach. While this provided important qualitative insights, it is subject to potential bias and may not fully capture the depth and breadth of students' experiences. Future research could consider incorporating additional qualitative methods, such as video recordings of classroom interactions, to provide a more nuanced understanding of the learning process. Third, while the study observed significant improvements in the experimental group's procedural and conceptual understanding, it did not explore the long-term retention of these learning gains. Future studies could include follow-up assessments to examine the sustainability of the learning improvements associated with the discourse-based learning approach. Finally, the study focused on multivariable calculus, a specific area of mathematics. While the findings are promising, it is unclear how applicable the discourse-based learning approach would be to other mathematical topics or subjects. Future research could explore the implementation and outcomes of this approach in different mathematical domains or even in other disciplines. In conclusion, the discourse-based learning approach shows promise for enhancing teacher students' understanding of multivariable calculus and warrants further investigation. By addressing these limitations in future research, we can continue to refine our understanding of this approach and its potential applications in mathematics education.

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Proceeding of The 10th Annual International Seminar on Trends in Science and Science Education (AISTSSE), FMIPA Universitas Negeri Medan, Indonesia, October 10Th, 2023

Implementation of Algebra Structure Teaching Materials Assisted With Concept Map Media Through Student-Centered Learning To Improve Proof Ability

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Abstract. *This study aims to develop teaching materials for algebraic structures assisted by concept maps through student-centered learning that is designed according to the cognitive level that is thought to be effective and efficient in increasing proof abilities. The subjects of this study were randomly selected undergraduate students of mathematics education. To find out the effect of student-centered learning models and teaching materials on algebraic structures assisted by concept map media developed, a pre-experimental research design was used with the One group pretest posttest design. Data collection techniques use quizzes, questionnaires, notes from lecturers and students, tests, interviews, and observation sheets which will be validated by mathematicians. Data were analyzed using descriptive analysis techniques, qualitative and t-test. Analysis Improvement in proving ability using N-Gain values. The research results obtained were* t_{count} *(11,379) >* t_{table} *(1,97658) and the magnitude of the increase in N-Gain was 0.47 which was categorized as moderate. The conclusion obtained is that proving ability is taught by student-centered learning by applying algebraic structure teaching materials assisted by concept map media to produce student learning activities, as well as positive attitudes and better student motivation.*

Keyword: Algebra Structure, Map Media, Proof Ability

Introduction

Algebraic Structure is one of the courses that is part of the pure or abstract group/group of analytical mathematics and algebra. It's a course that demands maximum proof skills and

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requires serious attention. As a pure mathematics course, the concepts contained therein are generally definitions, axioms and theorems that are arranged hierarchically. Even though the proof process is the main characteristic of mathematical activities that are carried out from when students are in elementary school to college, in college proof becomes a very serious obstacle, this is because the proof process at the college level is more formal and more accurate. The school curriculum states explicitly that students are expected to have mathematical competence in the form of skills in compiling evidence, namely elementary and junior high school students compose evidence inductively, while high school students compose evidence inductively and deductively. According to [10], the process of mathematical proof at the tertiary level is more formal and more accurate than proof in primary and secondary schools, namely by using deductive methods, namely implication, contradiction, contraposition, or direct proof, this is very difficult Once understood by students, this shows that the ability to prove needs special attention and becomes a key component in the learning process.

From the researcher's experience during teaching algebraic structure courses and from the results of Syafari's first year research, [17] shows that many students experience errors in the proof process, for example to prove the following form of implication: if $A \subset B$ then $B^c \subset A^c$. There are still many students who use $B^c \subset A^c$ to prove the problem above, even though the form $B^c \subset A^c$ is what will be proven. Another example: In the proof of the following theorem: A non-empty subset H of the group $\langle G,* \rangle$ is a subgroup of G if and only if $\cdot$ a,b $_n$ H holds $a * b^{-1}$ $_n$ H. Many students do not know what is known and what will be proven from the theorem.

From experience, researchers also show that things are not much different, many students do not understand the membership requirements of the following sets, for example H = { a $_n$ G | a x = x a , $\cdot$ x $_n$ G}, this can be seen when asked what are the requirements for being a member of set H? Understanding this concept is very important in the proof process, the same results were also obtained from the first year research results [20].

Judging from students' abilities, conceptual errors like the case above are very likely due to students' lack of knowledge of the prerequisites, students' attitudes that lack interest/motivation in studying the material, and students often remain silent and are afraid to ask questions, not daring to express ideas. Apart from the monotonous learning process using textbooks and presentations that do not take into account the level of cognitive abilities and real world context of students, this results in less than optimal student interaction, in addition to evaluations that only refer to results and not processes.

As a lecturer who teaches courses on algebraic structures, the problems above must of course be resolved early, by paying attention to the characteristics of the algebraic structure material, it is very possible to use learning using modules designed based on daily life problems, with the help of concept map media, as well as carrying out evaluations that apply authentic assessment. The researcher's experience when facing the problems above is trying to bring these problems into students' daily lives, for example, H is the Unimed Senate association, and G is the Faculty student association, what are the requirements to be a member of the H association? When this question is asked to students, most students begin to understand the problem above a little. Meanwhile, maximizing learning interactions between fellow students is carried out through a cooperative approach by maximizing the role of peer tutors. This is supported by the research results of [20] show that the cooperative learning process with the help of concept map media is able to improve students' proof and interaction skills. The results of this research also

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recommend that teaching materials are needed that are designed according to the cognitive level of concept maps and the world context. real students.

Algebraic structure material is one of the pure or abstract mathematics courses where the concepts contained therein are generally definitions, axioms and theorems which are arranged hierarchically, meaning that the concepts in algebraic structures are arranged from concepts and also facts. previous facts and continuous use of concepts to explain more abstract concepts. High level concepts are built from lower level concepts.

Thus, studying concepts in algebraic structures, especially those related to proof, will be more focused if students first arrange the concepts to be studied from the general to the most specific. Furthermore, for meaningful learning to occur, students' cognitive structures must contain relevant concepts, otherwise new information will be learned by rote. In reality, many teachers and textbooks rarely help students to use relevant concepts in their cognitive structures to assimilate new knowledge, resulting in meaningful learning not occurring but rote memorization.

[15] Suggests that this can be done with the help of concept maps based on Ausubel's theory. The three principles in Ausubel's cognitive theory in [16] that underlie concept maps are: 1) Cognitive Structure is organized hierarchically; 2) Concepts in the cognitive structure experience progressive differentiation, meaningful learning is a continuous process, where concepts are never completely studied, modified and made more inclusive; 3) Integrative adjustments, meaningful learning will increase if students are aware of the need for new relationships between concepts. In a concept map, this can be seen from the cross-links between concepts. For example: Concept map about Isomorphic Groups.

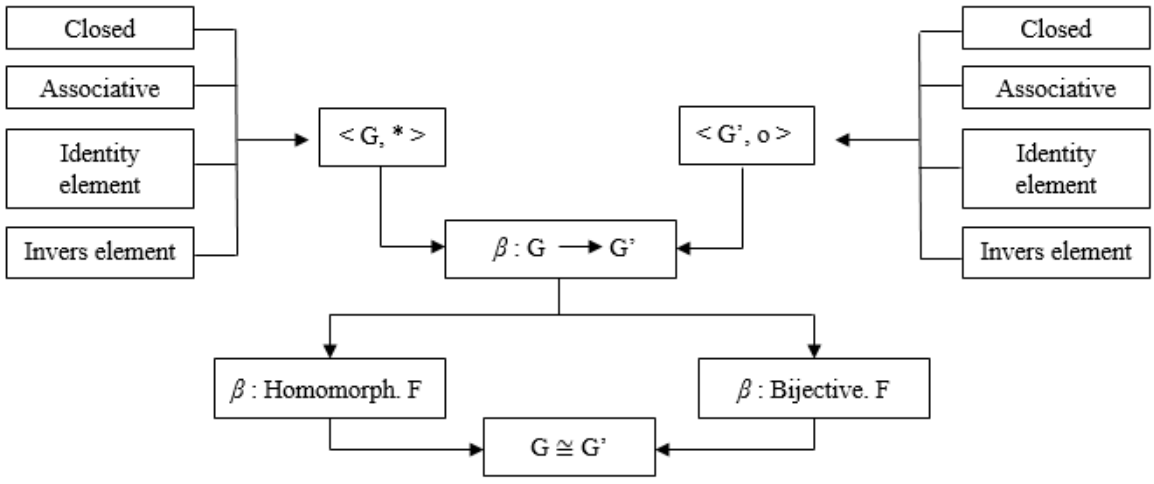

Figure 1. Concept map of the Isomorphous Group concept

Some relevant research results include the research results of [20] showing that remedial teaching with the help of concept map media can minimize student misconceptions in the Transformation Geometry and Real Analysis courses. Likewise, the results of research by [12] and competitive grants I and II of [21], show that cooperative learning with the help of concept map media can improve proof abilities in algebraic structures.

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Method

The subjects of this research were undergraduate mathematics education students who were randomly selected. The research method uses a pre-experiment with a One group pretest posttest design research design. According to [19], in the research design, before taking action, a test (pretest) is carried out and at the end of the learning a posttest (final test) is given. This design is used in accordance with the objectives to be achieved, namely wanting to know the improvement in the results of the treatment. The following is a research design table for One group pretest posttest design.

Table 1. Research Design

PreTest	Treatment	Posttest
O_1	X	O_2

The research flow and stages begin with the preparation stage, namely literature study, curriculum analysis and algebraic structure material, sample selection, and learning design and evidentiary ability instruments. Next, the implementation stage begins with a pretest (O_1), implementation of learning and ends with a posttest. The final stage involves data processing, analysis of research data, discussion, conclusions and preparation of reports. The following is a picture of the flow and stages of the research.

The research flow and stages begin with the preparation stage, namely literature study, curriculum analysis and statistical method material, sample selection, and learning design and comprehension ability instruments. Next, the implementation stage begins with a pretest (O_1), implementation of learning and ends with a posttest. The final stage involves data processing, analysis of research data, discussion, conclusions and preparation of reports. The following is a picture of the flow and stages of the research.

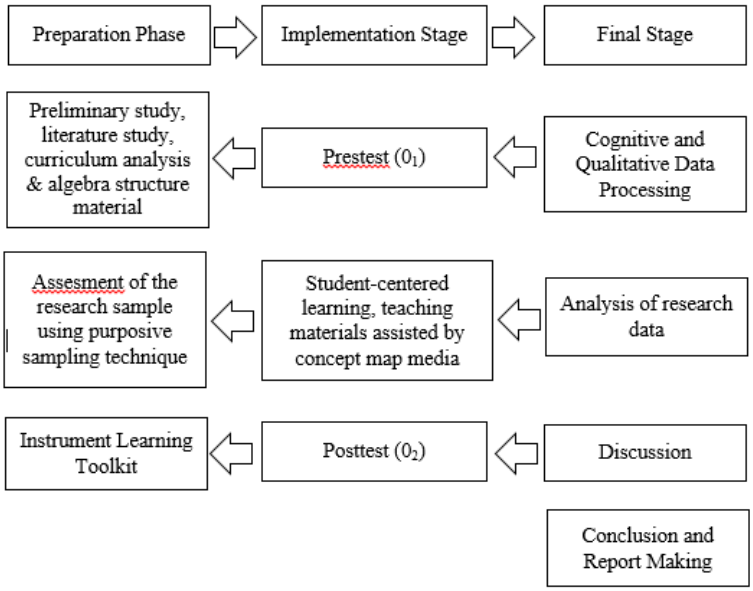

Figure 2. Research Flow and Stages

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Data for the preparation stage was obtained from a literature review related to the concept of student-centered learning as well as evidentiary ability instruments. Through validation from mathematics education experts, learning designs and instruments were obtained. Meanwhile, data at the implementation stage was obtained through quizzes, questionnaires, lecturer and student notes, tests, interviews and observation sheets. Lecturer notes, interviews, and observation sheets are used to determine the degree of application of the student-centered learning model used in the classroom. For the final stage, data processing is carried out from the research results obtained at the implementation stage.

The following are several aspects that are factors that cause problems in students' evidentiary abilities, including aspects of lecturers, students, methods/approaches, algebraic structure material, facilities. In general, the problems in this research are visualized in the following fishbone diagram.

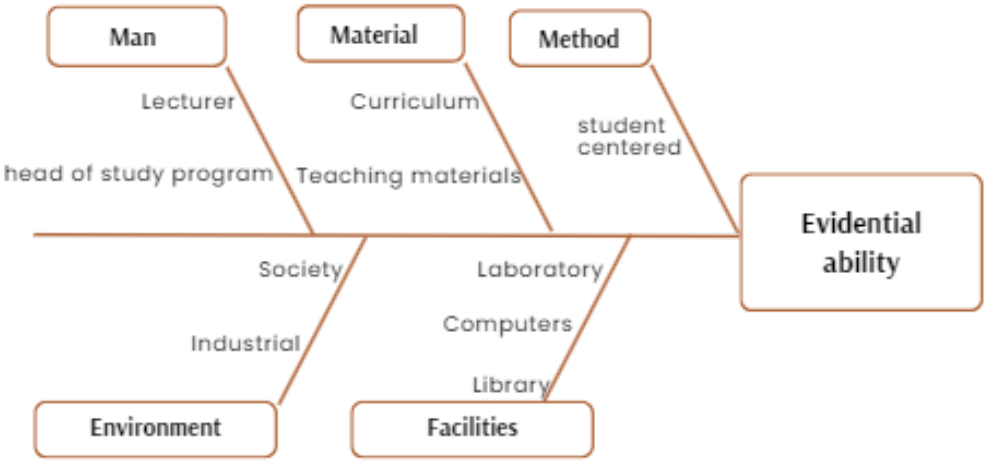

Figure 3. Fishbone Diagram

In the aspect of algebraic structure material, the suitability of concepts with prerequisite material and the cognitive level of students will be studied to formulate characteristics of proof abilities. Meanwhile, from the method or approach aspect, student-centred learning models will be studied. Through the lecturer aspect, lecturers' abilities will be studied in designing and developing teaching materials that are in accordance with the student-centered learning model. Meanwhile, from the student aspect, improvements in evidentiary abilities and learning models will be studied as an impact of the learning process. Furthermore, from the equipment aspect, support for teaching aids, libraries, labs and the classroom environment will be studied in implementing the learning process. Meanwhile, the environmental aspect will be studied by the school community in general and the encouragement of universities as providers of resources and human resources in realizing better educational improvements.

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Results and Discussion

The results of this research were one Mathematics Education class which was tested with a total of 70 students. The research was conducted during 16 meetings divided into 10 study groups to see students' evidentiary abilities in conducting centralized learning. Apart from that, from the results of the proof ability test, quite good results were obtained, and the positive attitude shown by the students made the process of learning algebraic structures assisted by concept map media through student-centered learning to improve proof skills better, the overall results are presented in the attachment. The results achieved from this research are presented as follows.

Pretest and Posttest Result Data

Analysis of pretest and posttest learning outcomes is carried out with the aim of measuring students' abilities before and after receiving the learning process, or in other words measuring the students' initial and final abilities in the material being taught. Below is a descriptive statistical analysis of pretest and posttest scores calculated using the SPSS 22.0 program.

Table 2. Descriptive Statistics of Pretest and Posttest Data

Score	N	Mean	Minimum	Maximum
Pretest	70	59.07	30	78
Posttest	70	76.43	56	95

Based on the data in the table above, it can be seen that the average pretest score is 59.07 with a maximum score of 78 and a minimum score of 30. Meanwhile, the average posttest score is 76.43 with a maximum score of 95 and a minimum score of 56. The graph of the data results is presented in **Figure 4** following.

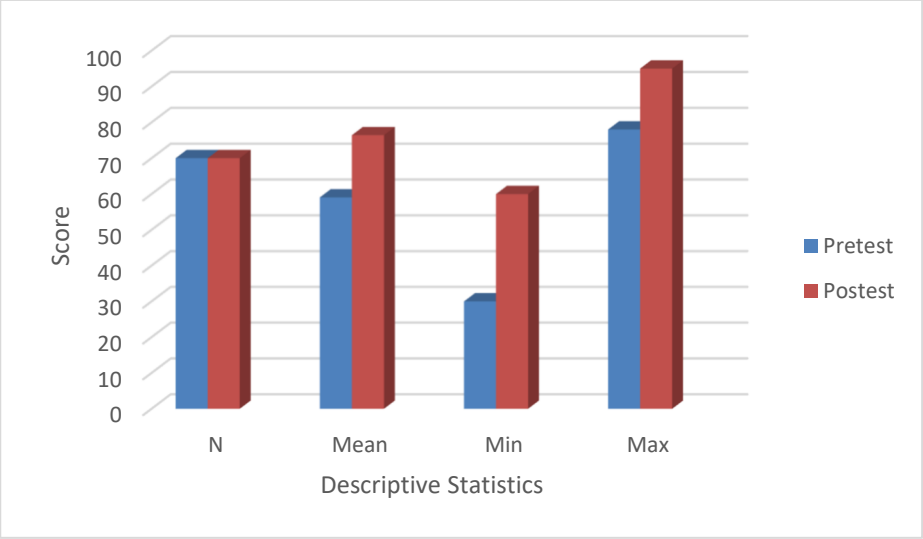

Figure 4. Average pretest and posttest scores

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By describing the data and paying attention to the graph, it can be seen that the average pretest and posttest scores have quite a big difference. However, to see whether the difference is significant or not, a statistical test will be carried out.

Pretest and Posttest Data Normality Test

The normality test was carried out to determine whether the data was normally distributed between the pretest and posttest. Normality testing uses Kolmogorov Smirnov test statistics with the help of the SPSS 22.0 program. The test results for the pretest and posttest are given in the table below.

Table 3. Normality Test Results of Pretest and Posttest Data

Score	Z	Sig. (P)	∝	Conclusion
Pretest	.095	.200	.05	Normal
Posttest	.103	.065		Normal

Based on the normality test calculation, the pretest obtained P = 0.200 and the posttest obtained P = 0.065. By comparing with the value ∝ = 0.05, it is obtained that the pretest value is P = 0.059 > ∝(0.05) and the posttest value is P = 0.200 > ∝(0.05). So it can be concluded that both data are normally distributed.

Posttest Data Homogeneity Test

The homogeneity test is carried out to determine whether the data has homogeneous variance or not. Test homogeneity of variance using the SPSS 22.0 program. The homogeneity test results for pretest and posttest data are given in the following table.

Table 4. Homogeneity Test Results of Pretest and Posttest Data

	Levene Statistic	Df1	Df2	Sig.
Value	3.801	1	138	.053

Based on the table above, the pretest and posttest P values obtained are P = 0.053. By comparing with the value ∝ = 0.05, then for P = 0.053 > ∝(0.05), it can be concluded that the data comes from a population with the same variance (homogeneous).

Pretest and Posttest Difference Test (Hypothesis Test)

After carrying out the normality test and homogeneity test of the data from the pretest and posttest results, it was discovered that the distribution of the pretest and posttest scores was normally distributed, so to test the difference between the two pretest and posttest means, the parametric statistical test t-test was used. The t-test used was paired samples (Paired Samples T Test) with the help of the SPSS 22.0 program and a significance level of 5%.

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Table 5. Pretest and Posttest T Test Results

Score	Df	Sig.(P)	∝	t_{count}	t_{tabel}
Pretest Posttest	138	.000	.05	11.379	1.97658

Based on the table above, it shows that significance (P) is 0.000. Due to the significance of P (0.000) < ∝(0.05), and t_{count} (11.379) > $t_{tabl\text{e}}$ (1.97658). This means that it can be concluded that there is an average difference between the pretest and posttest learning outcomes, which means that there is an influence of learning algebraic structures assisted by concept map media through student-centered learning to improve proof skills.

Gain Data Analysis Results

The gain value is obtained from the difference between the posttest value and the pretest value. Because learning outcomes are the results obtained by students after learning, the learning outcomes in question are improvements experienced by students. To determine the average difference between pretest and posttest learning outcomes, which means there is an influence of algebraic structure learning assisted by concept map media through student-centered learning to improve proof skills, a normalized gain calculation is used. The results of calculating normalized gain (g) on pretest and posttest learning outcomes can be seen in the table below.

Table 6. Gain Index Results for Pretest and Posttest Learning Results

	Pretest	Posttest	Gain	<g>	Category
Value	59.07	76.43	17.36	.42	Moderate

Based on the pretest and posttest value data, a normalized gain value of 0.42 was obtained. This value is interpreted into the <g> value criteria, namely $0.3 \leq g \leq 0.7$ so that student-centered learning is obtained by applying algebraic structure teaching materials assisted by concept map media through student-centered learning to improve the ability to prove which is classified as moderate.

Conclusion

The average results of the proof ability of centralized learning obtained were t_{count} (11.379) > $t_{tabl\text{e}}$ (1.97658) which shows that there is an influence of learning algebraic structures assisted by concept map media through student-centered learning to improve proof ability and able to produce student learning activities, as well as positive attitudes and better student motivation.

Acknowledgments

Finally, I would like to thank the Chancellor and Chairperson of LPPM Unimed who have provided full support, motivation and funds for this research. Hopefully the results of this research are useful.

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Proceeding of The 10th Annual International Seminar on Trends in Science and Science Education (AISTSSE), FMIPA Universitas Negeri Medan, Indonesia, October 10Th, 2023

Students' Weaknesses in Learning Fractions Using Newman's Errors Category

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Abstract. *This study aimed at analyzing students' weaknesses in learning Fractions by using Newman's Student Error Category: reading, understanding of the problem (comprehension), transformation, process skill, and written answer error (encoding). It was descriptive research with a class of 32 students of grade 7 in SMPN 22 Medan. The study showed that 4 students were in the level of Specials or No Answer, 3 students were in the level of Basic, meaning that the data unused or strategy unknown and none of the students are in the level of or doing good strategy but less effort, 9 student was in the level of Competent or doing a good strategy but conduct an error solution or small mistakes and 16 students were in the level of Proficient or doing the correct answer. The Newman's Errors Category of the students' weaknesses in learning Mathematics that was still found in SMP were: (1) reading errors (difficulties in understanding the problems and the problem condition); (2) reading comprehension difficulties (students did not write the question and the data/information of the problem); (3) transformation errors (students did not write the correct procedure to solve the problems and did not get the complete procedures); (4) process skill errors (students did not use the math operation correctly and execute the strategies completely); and (5) careless errors (students gave incorrectly writing answer, did not write the answer correctly, and did not give any conclusion).*

Keywords : Students' Weaknesses, Mathematics Numeracy Literation, Newman's Errors Category

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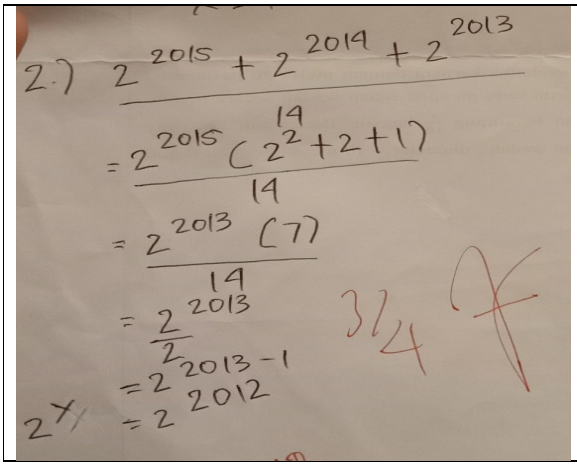
Rationale/Background

The study of [2] mentions that there is an increased ability for students to learn numerical literacy of mathematical lessons in SMPN 14 Medan. It is reviewed by students' ability to complete the numerical literacy material found in the ion of junior high math lessons that researchers have prepared. The category of student numeration literacy skills consists of: ***special*** (students have limited mathematical knowledge and indicate partial concepts mastery and limited computing skills), ***basis*** (students have basic mathematical skills; Basic math computing and resolving simple routine math problems), ***competent*** (students can apply mathematical knowledge in varying contexts) and ***proficient*** (students are able to reason for complex and nonroutine problems). Research data indicate that there is a tendency (1) that the number of specially valved students tend to decline (none), (2) the number of elementary valour students tend to decline, (2) the number of qualified students increases, and (3) the number of proficient students increases. However, there are still mistakes of understanding and application of concepts, operations and mathematical procedures in resolving mathematical numerations. One is like this



The student's mistake is that they are not able to deduce the variable value derived from the same base income.
This means that students do not have an understanding of the meaning of rank and the application of the advanced operations. Students are at a special level so that it may be concluded that students do not have the mathematical literacy ability to understand the process and implement the operating procedures of the ranks, especially in the use of the distributive properties of the sum of the number.

Figure 1. An example of student's weaknesses in learning Mathematics Numeracy

The numerical literacy weakness comes after the practice of numerical lessons in 14 fields for 4 weeks of run-up. Intensive learning through a scientific approach is implemented by leverizing numeration literacy (RPP, mathematics teaching materials, student's learning activity sheets, and numerical literation test). The observation of the learning device was stated valid and practical for use in learning student numeration literacy in schools.

Another weakness is in numerical literacy study was in implementing the scientific learning approach. This was viewed from applying the flow (syntax) of the teacher's saintifical approach to distributing mathematical matter in numerical literacy. Data indicated that the course of scientific learning (observing, asking, gathering information, searching, and communicating) did not go as expected. Student activities in all five activities are not managed by sequential and fluent activities that reduce students' activities to think critically, analistic, and appropriate in identifying, understanding, problem solving, and applying mathematical learning materials in solving junior high math numerical literacy problems.

According to [11] that mathematical numerical literacy ability is the ability to use numbers, symbols and mathematical procedures to solve the problems of daily living, and the ability to analyze information in various forms of representation such as tables, charts, charts, and others. In addressing the problem, students involve the ability to apply facts, concepts and

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rules of mathematics, although unstructured issues, have many possible solutions or no relevant solutions. Numeration literacy in this study is defined as the students' ability to apply mathematical knowledge to solving the various contexts of everyday life [9]. Among the indicator of numerical literability is the understanding of mathematical representations of Numbers, symbols and mathematical procedures; His application in resolving the problem of the various contexts of daily life, and reasoning (analysis, evaluation and creation) the various information presented in the form of charts, tables, charts, diagrams and others in order to assess and make decisions.

[5] States that the increased numeration strategy can be done with the innovative model/ approach/method and learning tools (books, RPP, and student's learning sheets) done by teachers. It is also recommended by other researchers such as [3,7]. With that in mind the study designed the use of a saintifik approach based on case-method and project based learning to develop learning tools of the high-intensity math numeration books in the field and increase the numerical literacy of junior high school students.

In solving Mathematics problems or in learning Mathematics, especially in learning Literation Numeracy, there are several factors that make Mathematics was much harder to solve: (a) position of question on the problems, (b) the specific levels in words problems, (c) magnitude of numbers, (d) the number of the operation used in completion of the problem, and (e) the use of Mathematics teaching aids. In the search of student's mathematics weaknesses, Newman error analysis was the first time introducing by Newman in 1977 [1,6]. In the Mathematics learning, the error problems are differentiated into five types of errors, that is (1) Reading error (identifying precise and complete mathematical information and symbols), (2) error of understanding (misunderstanding or written correctly known and questioned), (3) Transformation error (deep error transformation which is to write precise, complete mathematical models), (4) the process skills errors which is using the right process and the right answer, (5) encoding error (mistakes on notation). Several studies has been done in several location in Indonesia such as [4,10]. They were concluded that in the subject of Arithmetic it was found that 8.3% of students conducted the reading errors, 13.6% of students conducted the reading comprehension errors; 14.9% of students conducted transform error; 31.8% of students conducted process skill errors and 31.8% conducted the encoding errors. In the subject of Linear Equation it was found that 5% of students conducted the reading errors, 46.4% of students conducted the reading comprehension errors; 63.6% of students conducted transform error; 74,8% of students conducted process skill errors and 87,9% conducted the encoding errors.

In this research the subjects of Mathematics that was being studied were about Numbers (Integers and Fractions). In what criteria of Newman Analysis Errors were being conducted by the students in SMPN 22 Medan and how many students were conducted these 5 categorization of Newman's Errors. It is hoped that this study will give many advantages to the research community of Mathematics Learning and the theory of mistakes in the numeracy literation learning process.

Methods

This study aims at analyzing the student's performances in learning mathematics numeracy literacy using Newman's category of student's learning difficulty. The study used a qualitative method, in which the researcher analyzed the weaknesses phenomenon faced by the subject of the study. Later the result was described in the form of word and language in a particular context that is natural and utilizing various scientific methods [8].

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The study was done in SMPN 22 Medan in the year of 2022/2023. The subject of this study was 32 students in the class VIII F. The technique of choosing the observing subject was done with purposive sampling technique. According to [12], the sampling technique is a sample taking the technique from the data source with a specific consideration [12].

The technique of collecting data was using test and observation. The observation was focused on the errors done by the students in the test answer. Observation was divided based on the type of errors namely reading, comprehension, transformation, process skill, and decoding. At the end, the data were analyzed with reducting the student's difficulties with the students' ability to solve problem classification result based on the type of errors and later the data was presented in form of table and description and classified and concluded [12]. The table of the level of Numeracy categorization of competencies is as below.

Table 1. Table of the level of Numeracy categorization of competencies

Skor	Level of Numeracy Competencies	CRITERIA
0	**SPECIAL** Limited	○ Matter not done or blank papers ○ Data is incorrectly written and not used ○ Incorrect answer
1	**FIRST BASIS** Basic Comprehension	• Data rewritten but not used • There is a correct strategy but not applicable to the problem • Inadequate results
2	**SECOND BASIS** Comprehension	○ There is strategy, used but incorrect answers ○ The job is not good enough to achieve an answer ○ Correct answer but no craftsmanship strategy being used but incorrect answers
3	**COMPETENT** Application	Concepts, procedures, and strategies are correct but there are miscalculations of operation
4	**PROFECIENT** Reasoning	Concepts, procedures, and strategies are correct and calculating operations are correct

Results and Discussion

The following table was the result of student's competencies in learning literation numeration of the subject of Fraction in mathematics.

Table 2. Level of Numeration Literacy of the Students with its Criteria

Skor	Level of Numeracy Competencies	CRITERIA	Numbers of Items			Whole Class
			1	2	3	
0	**SPECIAL** Limited	○ Matter not done or blank papers ○ Data is incorrectly written and not used ○ Incorrect answer	1	1	2	**4**
1	**FIRST BASIS** Basic Comprehension	• Data rewritten but not used • There is a correct strategy but not applicable to the problem • Inadequate results	6	4	5	**3**
2	**SECOND BASIS** Comprehension	○ There is strategy, used but incorrect answers ○ The job is not good enough to achieve an answer ○ Correct answer but no craftsmanship strategy being used but incorrect answers	2	2	2	**0**
3	**COMPETENT** Application	Concepts, procedures, and strategies are correct but there are miscalculations of operation	9	14	21	**9**
4	**PROFECIENT** Reasoning	Concepts, procedures, and strategies are correct and calculating operations are correct	14	11	2	**16**

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For the second item of literacy test, there were: (a) only a students that is not doing at all of solving the problem; (b) 4 students were in the level of basis or the basic comprehension level, meanings that the students had an inadequate results of the calculation; (c) 2 students were in the level of second basis or the comprehension level, meanings that the students applied the strategy but resulting on the incorrect answers or having a correct answer but no calculation; (d) 14 students were in the level of competent or the application level, meanings that the students applied a correct answer but had a small mistakes (miscalculations of operation) in doing the strategy; (e) 11 students were in the level of proficient or the reasoning level, meanings that the students used a correct answer and its strategy.

For the third item of literacy test, there were: (a) 2 students that is not doing at all of solving the problem; (b) 5 students were in the level of basis or the basic comprehension level, meanings that the students had an inadequate results of the calculation; (c) 2 students were in the level of second basis or the comprehension level, meanings that the students applied the strategy but resulting on the incorrect answers or having a correct answer but no calculation; (d) 21 students were in the level of competent or the application level, meanings that the students applied a correct answer but had a small mistakes (miscalculations of operation) in doing the strategy; (e) 2 students were in the level of proficient or the reasoning level, meanings that the students used a correct answer and its strategy.

For the whole class of 32 students in solving the item of literacy test, it can be stated that there were: (a) 4 students (12,5%) in the level of special level; (b) 3 students (9%) were in the level of the basic comprehension; (c) no students were in the level of second basis or the comprehension level; (d) 9 students (28%) were in the level of competent or the application level; (e) 16 students (50%) were in the level of proficient or the reasoning level. By having this results, it can be concluded that 25 students out of 32 students, it is 78% of the students is having a very good understanding of literacy numeracy of Mathematics. There were still 22% of the students had a difficulties in learning numeration literation of Mathematics. The followings are the explanation of their weakness.

In solving the pre-test of numeracy literation, the Newman Analysis Error has been done from the student's answer sheet. The followings are the categorization errors.

1) Reading Error

The criteria for reading error, which is: (1) students do not work out the problem and the criteria, and (2) students immediately write the final incorrect answer. From the analysis of the student's answer sheet found errors of the student's reading level that students immediately write down incorrect final answers on the given problem and students did not. Here is an example of misreading done by students in pre-test matters.

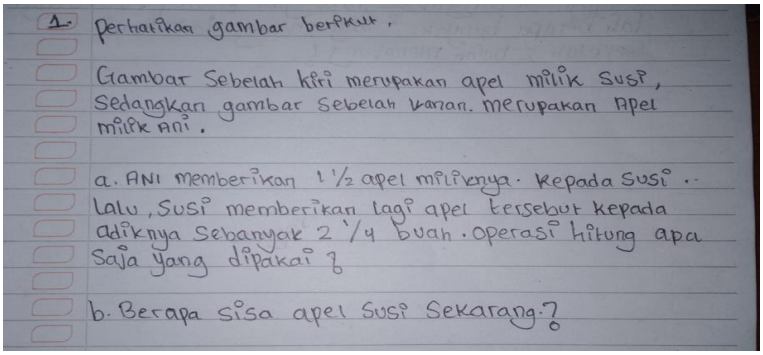

Figure 2. Student CYS answer for the item 1

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It seems that CYS students are misreading. Based on the CYS' answer sheet it can be known that CYS does not understand the problem and does not answer the question. CYS students just rewrote the problem. This is because CYS has no meaning to the problem that causes cys to be unable to solve the problem because CYS made a mistake in the first stage of the reading phase, so that it cannot continue to the next.

2) Reading Comprehension Difficulty

The second indicator is the difficulty of reading. The error criterion of understanding is that there are two, the first criterion of a student not writing down what is known and asked about and the second criteria of the student is incomplete in writing what is known and asked about. Here is an example of the difficulties students are making in reading. This is the Student YAS answer for the item 1.

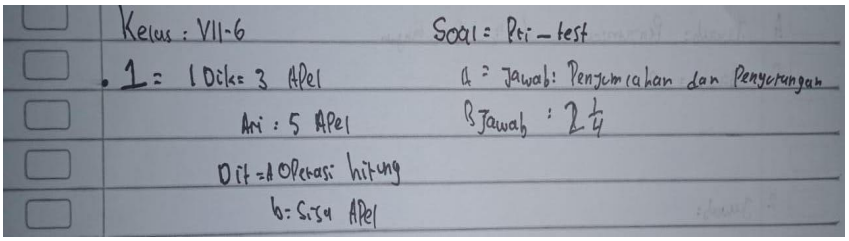

Figure 3. Student YAS answer for the item 1

It appears that the student YAS answer sheet is incomplete to write down what is known and is asked in the matter. This suggests that jaas did not understand the information presented in the problem. This is seen at the next stage where yas isn't able to solve problems correctly.

3) Transform Error

The criteria in transformation error (transform error) is two, the first criterion that students do not write down the method used and students do not complete the method used in solving the problem. Here is an example of the transformations that students make on pre-test subjects. This is the answer of students JL on item number one.

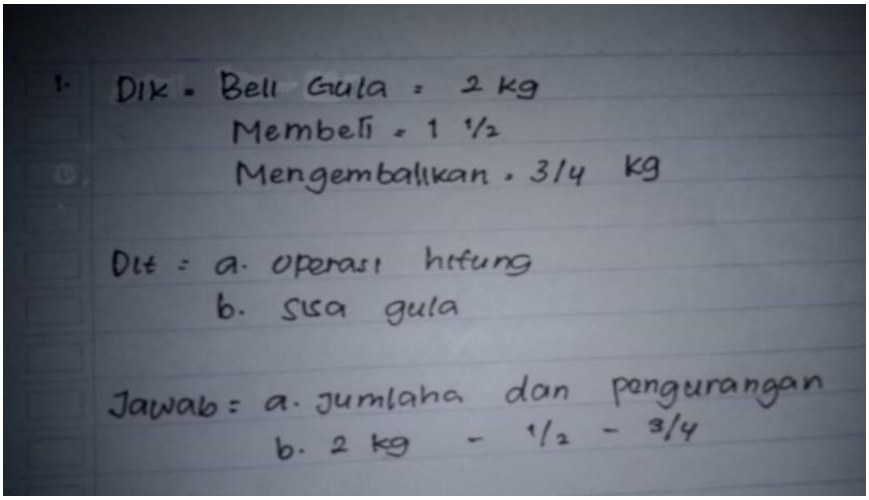

Figure 4. Student JL answer for the item 1

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It appears the student JL does not write down the method used. He is unable to write up the fraction count operation. It suggests an error in transforming which is incapable of determining the method used to solve the problem. Most likely it is just an answer to solve the problem without doing the phase of the solution.

4) Weakness in Process Skill

The criteria for the miscalculation of the skill skill (advanced in charge) are two, the first criteria of the student being wrong in performing count and the second criteria of the student not writing and completing the method. Here is an example of an error in the process skills made by students. Here is student DM's answer on problem 2.

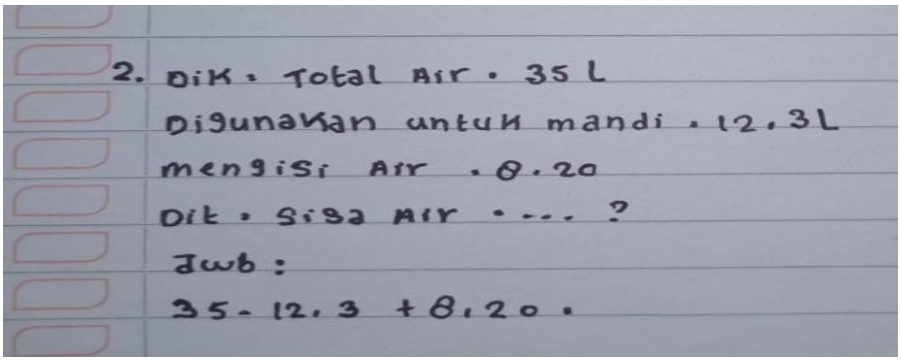

Figure 5. Student DM answer for the item 2

It appears that student DM is unable to continue to calculate the fraction operation he has made. Students DM is clear about changing the problem in a mathematical sentence but are unable to complete the method he has created. Therefore DM is having a hard time in process skills.

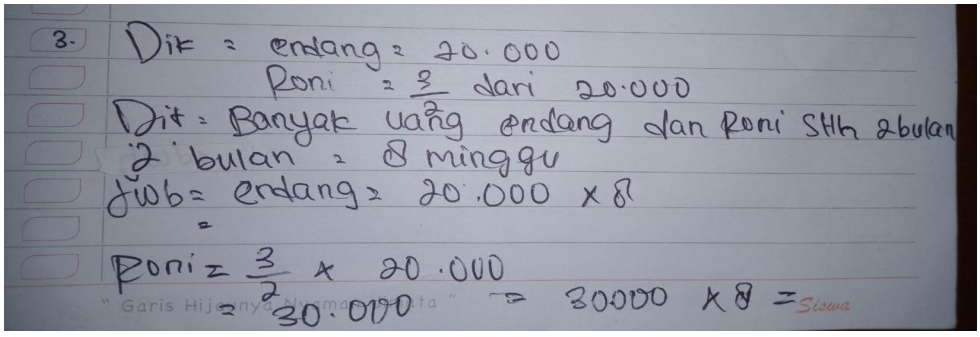

Figure 6. Student RF answer for the item 3

It appears that student RF is unable to complete the methods he has created. The student RF is fluent in changing the problem in a mathematical sentence but is unable to complete the method he has devised. Therefor RF has difficulty in process skills.

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5) Careless Error

At the level of the student answer sheet analysis the criteria for making it easier for the researcher to pinpoint the student's faults. The criteria of error are made according to the adjusted from the error indicator. The criteria in the misdirection of an answer is three, the first criteria is that students do not write answer conclusions, the student's second criteria do not write answers and the student's third criteria are incorrect in writing answers. Here's a sample of the careless mistakes the students make. Here's MR's answer on problem number 2.

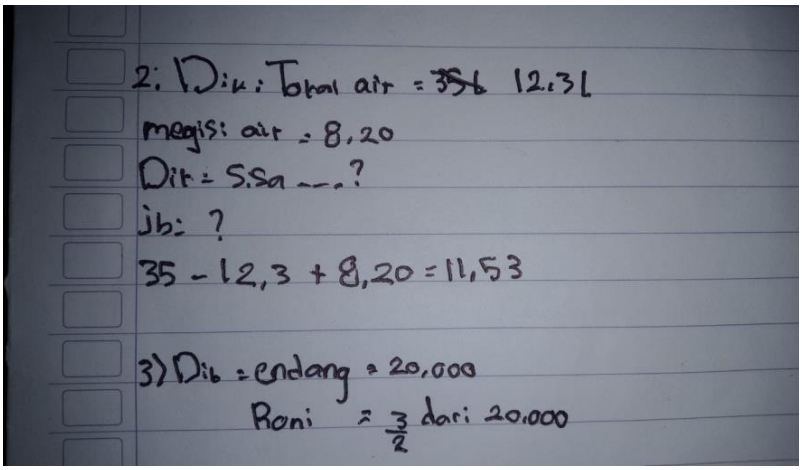

Figure 7. Student MR answer for the item 2

It appears that student MR made a mistake at the writing point of the answer that MR miswrote the final answer that should have been 30.9 litres. Students are unable to complete the method used in the problem. This transformation is closely related to the skill of the process in which if an error in the transformation of the student does not complete the method then the calculating process does not end and it causes a mistake at the critical stage of error, in which the student is unable to write the final answer.

The answer of student CRR on the item number 3

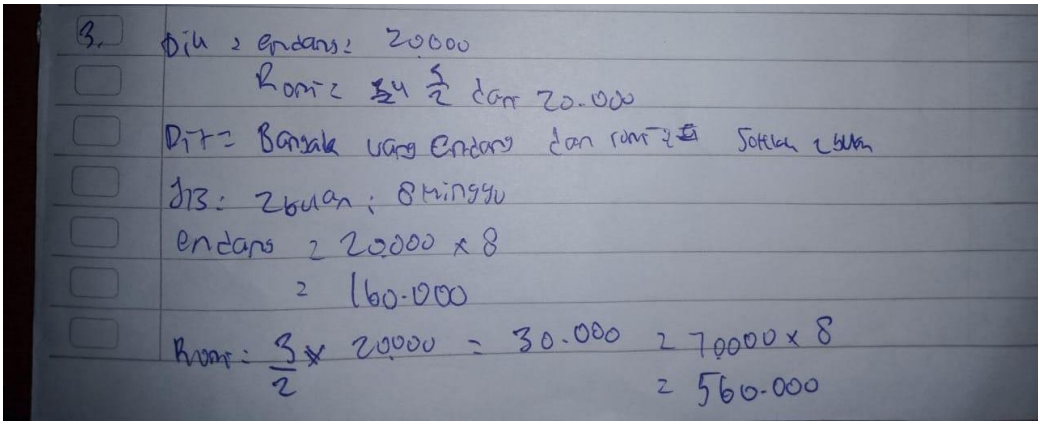

Figure 8. Student MR answer for the item 3

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It appears that CRR students made a mistake at the writing of the answer as CRR miswrote the final answer that should have been 240,000 for a savings account. Students are unable to complete the method used in the problem. This transformation is closely related to the skill of the process in which if an error in the transformation of the student does not complete the method then the calculating process does not end and it causes a mistake at the critical stage of error, in which the student is unable to write the final answer.

In solving the post-test of numeracy literation, the Newman Analysis Error has been done from the student's answer sheet. The followings are the categorization error.

1) Reading Error

The criteria for locating reading (reading error), which is: (1) students do not work out the problem and the criteria and (2) students immediately write the final incorrect answer.

From the analysis of the student's answer sheet found errors of the student's reading level that students immediately write down incorrect final answers on the given problem and students did not. Here is a sample of the misreading students made on the matter of post-test. Here is the student RAS's answer on problem number 3.

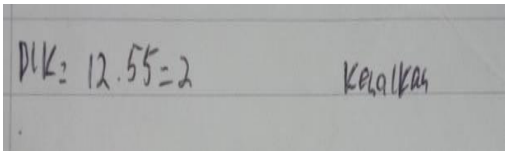

Figure 9. Student RAS answer for the item 3

It looks like the student RAS made a mistake reading. Based on the RAS's answer sheet it may be known that race did not understand the issue and miswrote its meaning. RAS doesn't write down methods and doesn't joy-randomly on the answer sheet. This is because race has no meaning in what causes RAS to be unable to resolve the problem because RAS makes a mistake in the first stage of the reading, and is therefore unable to move on.

2) Reading Comprehension Difficulty

The second indicator is the difficulty of reading. The error criterion of understanding is that there are two, the first criterion of a student not writing down what is known and asked about and the second criteria of the student is incomplete in writing what is known and asked about. Here is an example of the student's difficulty in reading on the post- test matter. Here's student RKZ's answer on problem number 3.

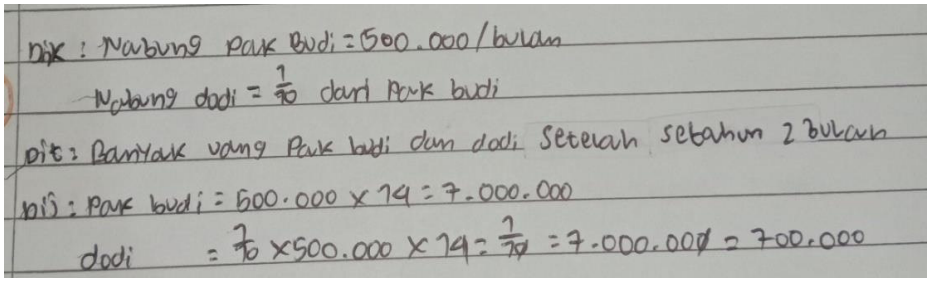

Figure 10. Student RAS answer for the item 3

It appears that RKZ's answer sheet is incomplete to write down what is known and asked in the matter. This suggests that RKZ did not understand what information is contained in the problem. This is seen at the next stage where RKZ is unable to resolve problems correctly.

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3) Transform Error

The criteria in transformation error (transform error) is two, the first criterion that students do not write down the method used and students do not complete the method used in solving the problem. Here's an example of the transformation errors that students did on the matter of post-test. Here's the student VP's answer on problem number 2.

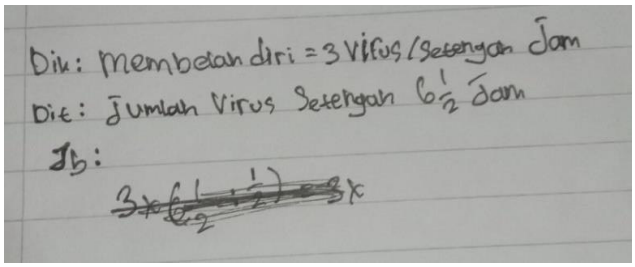

Figure 11. Student VP answer for the item 2

It seems that VP students don't understand the methods used, can't write down the fraction count operation. This shows VP made a transformation error which the VP was unable to determine the methods used to solve the problem. Probably the student VP was just guessing answers to solve the problem without doing the phase of completion.

4) Weakness in Process Skill

The criteria for the miscalculation of the skill skill (advanced in charge) are two, the first criteria of the student being wrong in performing count and the second criteria of the student not writing and completing the method. Here is an example of an error in the process skills students perform on the post- test matter. Here's the student's answer on problem number 3.

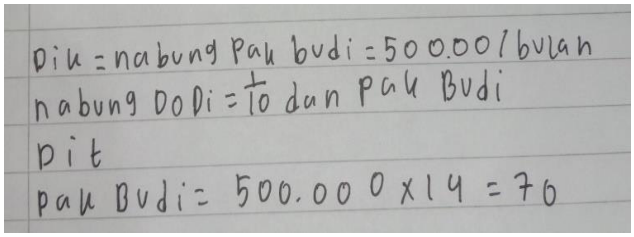

Figure 12. Student SA answer for the item 3

It appears that the student SA made a mistake in calculating his methods. The student SA is wrong to perform a count and not write and complete the method.

5) Careless Error

A careless one, that is, a lapse of carelessness or indiscretion. In solving math problems, you can often find errors in the solution process. Here's an example of the transformation errors that students did on the matter of post-test. Here's the cys student's answer on problem number 3.

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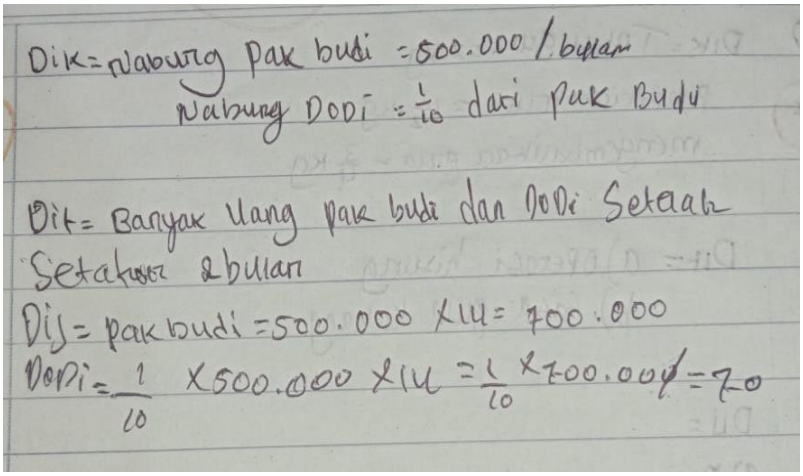

Figure 13. Student CYS answer for the item 3

It seems that student CYS blundered inappropriately get an end result of his methods. It appears that student CYS were less careful and too hurried - so rushed in counting that the answers were incorrect. Therefore, the student CYS made the mistake of being careless.

Conclusion

For the whole class of 32 students in solving the item of literacy test of Fractions, it can be stated that there were: (a) 4 students (12,5%) in the level of special level; (b) 3 students (9%) were in the level of the basic comprehension; (c) no students were in the level of second basis or the comprehension level; (d) 9 students (28%) were in the level of competent or the application level; (e) 16 students (50%) were in the level of proficient or the reasoning level. By having this results, it can be concluded that 25 students out of 32 students, it is 78% of the students is having a very good understanding of literacy numeracy of Mathematics.

The Newman's Errors Category of the students' weaknesses in learning Mathematics that was still found in SMP were: (1) reading errors (difficulties in understanding the problems and the problem condition); (2) reading comprehension difficulties (students did not write the question and the data/information of the problem); (3) transformation errors (students did not write the correct procedure to solve the problems and did not get the complete procedures of Fractions); (4) process skill errors (students did not use the math operation correctly and execute the strategies completely); and (5) careless errors (students gave incorrectly writing answer, did not write the answer correctly, and did not give any conclusion).

Acknowledgments

My appreciation and gratitude to LPPM UNIMED that give the fund to do this research in SMPN 22 Medan for the year of 2023.

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Enhancement of problem-solving Skills Student's Completed Creativities Programs Development

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Abstract. *The objectives of this research are going to establish and manage creativity programs that can improve the level of problem-solving skills of students. The ability to solve problems is essential for students to succeed in a variety of subjects. This research considers developing creativity programs that not only hold problem-solving skills students, but also nurture critical thinking, innovation, and collaborative teamwork. The research methodology is comprised of research and development methods. There are nine stages in developing a student creative program, which include collecting data, planning, developing a preliminary product, validating, conducting preliminary field testing, operational product revision, operational field testing, final product revision, dissemination, and implementation. Students at Universitas Negeri Medan who participate in community student activities (UKM) are the research's subjects. This research led to the development of creative programs that foster critical thinking, innovation, and collaborative teamwork to improve student's problem-solving skills.*

Keywords: problem-solving skills, creative programs development, critical thinking, innovation, collaborative teamwork

Introduction

The Industrial Revolution 4.0, highlighted by the integration of digital technology, artificial intelligence (AI), Internet of Things (IoT), big data, and other related technologies, has brought about many significant changes in various sectors. However, while bringing opportunities, the Industrial Revolution 4.0 also creates a number of challenges for creativity. This challenge indirectly forces higher education personnel to prepare themselves as graduates who have the creativity to face the changes impacted by the Industrial Revolution 4.0. Digitalization, optimization and quality of human resources are problems and challenges in the current generation [1]. The Indonesian government is trying to prepare highly competitive and superior human

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resources to face the industrial era 4.0. Excellent human resources are a group of Indonesian labor force that is professional, productive, able to compete, and ready to face global challenges and the industrial revolution 4.0. The Indonesian government designed Making Indonesia 4.0 as an integrated roadmap to implement a number of strategies in entering the Industrial Era 4.0 which is a big leap for the industrial sector, with information and communication technology simultaneously being fully utilized [2-5].

Based on the results of a survey of students who are actively involved in 12 Unit Kegiatan Mahasiswa (UKM) and the Senate Mahasiswa Unimed, the data shows that the management of the 13 UKM programs has not shown a good level of creativity. Another fact found is the low quality of creativity proposed through the Program Penguatan Kapasitas Organisasi Kemahasiswaan (PPK ORMAWA) in 2023. This condition is a rational reason that efforts are needed to increase the creativity of UNIMED students. Increasing student creativity is intended through the development of student programs to improve the problem-solving skills of Unimed students. Based on the above background, the formulation of this research problem is how to develop a programs creativity to improve problem solving skills.

Literature review

In the assessment study of problem-solving skills, the cognitive process plays an active role. According to [6-8], the stages of thinking that are the basis for problem solving are as follows: 1) formulating problems, knowing and finding problems clearly; 2) examine the problem, use knowledge to detail, analysis the problem from various angles; 3) formulate hypotheses, imagine and appreciate the scope, cause and effect and alternative solutions; 4) collect and classify data as material for proving hypotheses, skills in finding and compiling data, presenting data in the form of diagrams, pictures; 5) proof of hypotheses, ability to examine and discuss data, calculate and connect, decision-making skills and conclusions; and 6) determine the choice of solution, the ability to make alternative solutions, the ability to assess choices by taking into account the consequences that will occur at each step.

According to [9], four important factors are aspects of creative thinking ability, namely: a) Fluency of Thinking: The ability to generate many ideas quickly. In fluency of thinking what needs to be determined is quantity not quality; b) Flexibility of thought: The ability to produce a number of varied answer ideas or questions, see a problem from a divergent point of view and be able to use various approaches or ways of thinking. Creative people are flexible thinkers; c) Elaboration of thinking; The ability to develop ideas and add or detail the details of an object or situation so that it becomes more interesting; d) Originality of thought: The ability to come up with unique or original ideas.

Method

This research is a research-based development that has as a goal the enhancement of the quality of education graduates. In addition to developing and validating educational outcomes, this development research is used to develop a program that can improve the problem-solving skills of Unimed students based on the level of creativity. The implementation of the program indicators, the students' responses and the changes in the improvement of Unimed students' problem-solving skills based on the level of creativity were observed using the qualitative research method. According to [10]: "Educational research and development (R & D) is a process used to develop and validate educational production" based on this quote, research and development is carried out

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cyclically and each step to be carried out refers to the previous results until it produces a new program. The subjects of this research are all the students of the Unimed who are registered in the 12 Unit Kegiatan Mahasiswa (UKM) and Senat Mahasiswa Unimed. The product of this research is an information system for fostering student activities and guidelines for student activities as initial knowledge in participating in student competitions ranging from regional, national, to international levels. A number of steps in this approach were suggested by [10], namely "research and information collecting, planning, develop preliminary form of product, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing, final product revision, and dissemination and implementation.

Data collection in this study used instrument development in the form of questionnaires, observation guidelines, and interview guidelines. These three instruments are an integrated set for the measurement of problem-solving skills on the basis of creativity activities. Student program that focused on fostering creativity include student participation in the annual "Program Kreativitas Mahasiswa (PKM), which is coordinated by the Direktorat Pembelajaran dan Kemahasiswaan, Kemendikbud-Dikti.

Result and discussion

Refer to the indicators of problem-solving skills on [11] and [12], the result of the analysis, obtained from the field by involving several lecturers as a team, stated that it needs more attention and needs to improve the ability of the problem-solving skills of the students. The results of the analysis of students' problem-solving skills are presented in table below.

Table 1. Score of students' problem-solving skills

Indicators	Score	Categories
Understanding the problem: Students will be able to identify and define the problem in a clear and in-depth manner.	75	Good
Analyse the problem: The ability to analyse the problem by sorting it, extracting the data and identifying the root cause of the problem.	62	Lack
Critical thinking skills: The ability to question assumptions, see multiple perspectives and rationally evaluate solutions.	60	Lack
Decision-making skills: Students are able to make the right decision based on having analysed the problem.	65	Enough
Creativeness: The ability to come up with creative ideas and innovative solutions to complex problems.	70	Good
Planning and Strategy: The ability to plan concrete actions to address problems, including the development of appropriate strategies and measures.	68	Enough
Using tools and methodologies: The ability to use relevant tools and methods to solve problems, including techniques for analysing data or using specialized software.	67	Enough
Communication skills: Ability to clearly explain problems and solutions, both in writing and verbally	75	Good
Cooperation and collaboration: The ability to work in teams, share ideas and collaborate with others in the search for solutions.	70	Good
Review and evaluation of the results of the problem-solving strategies implemented	66	Enough
Average	**67.8**	**Enough**

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The data in Table 1 describe that students' problem-solving skills are concluded to have a sufficient level of creativity. However, the indicators of problem analysis and critical thinking are still lacking. This must receive attention in the development of Unimed's student activity program.

According to the data presented in Table 1, the results of the analysis carried out with the team collecting the data obtained information related to the level of creativity of the students. The results of the analysis indicate that the average obtained indicates that the level of creativity of the students is in the less category. In the following, the results of the level of creativity of the students are presented in Table 2.

Table 2. Score of students' problem-solving skills

Indicators	Score	Categories
Originality: Measures the extent to which the ideas or works are original or non-stereotypical. The more unusual or out-of-the-ordinary the idea is, the higher the level of creativity will be.	60	Lack
Quality of the idea: Measures how good or innovative the ideas are. Ideas with greater impact or a more unique solution are considered more creative.	58	Lack
Flexibility of Thinking: The ability to solve a problem or task by thinking flexibly and considering different alternatives.	63	Lack
Peer recognition: Whether one's idea or work is recognized or appreciated by peers or similar communities as creative.	66	Enough
Development of problem solutions: The ability to generate innovative and effective solutions to complex problems.	65	Enough
The ability to solve problems: Creativity in the identification of problems and the development of innovative solutions to those problems.	63	Lack
Average	**62.5**	**Enough**

The results of this field analysis show that the level of student creativity implemented in problem solving either in studies or student activities is concluded in the less category, with a score of 62.5.

The development of student activity programs is considered necessary from planning, implementation, monitoring, and evaluation. Each stage is carried out in a careful manner and to ensure that the improvements and gains found do not affect the implementation of the program. The purpose of this program development produces several fields including a) the development of reasoning and creativity programs, b) the field of achievement improvement and development, e) the field of spirituality, and f) the field of internationalization following the program development scheme, as presented in Figure 1.

Based on the results of field data analysis, a scheme to improve students' problem-solving skills is needed through the development of student activity programs that focus on creativity or reasoning. Strengthening the competence of problem-solving skills and student creativity is designed by involving all student affairs managers from the university level, faculty, to the department level. In addition to student affairs managers, collaboration with academic units, especially those related to the curriculum, is a partner in synchronizing student activity development programs.

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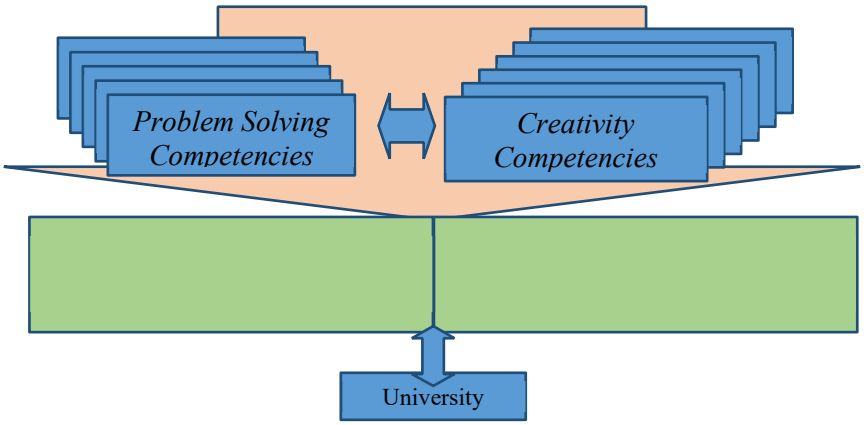

Figure 1. Scheme to develop students' problem-solving skills

Conclusion

This research aims to develop and improve problem-solvers with a focus on creativity. In this way, the conclusions of this research are as follows 1) Improving problem solving skills focusing on creativity is a competency that must be possessed by students with lecturers as facilitators. The ability of problem-solving skills focusing on creativity can enable students to be involved in the excellent program in the field of student affairs of the Ministry of Education, Culture and Research that must be developed by Unimed. The activities are based on 1) the main activities, 2) the program of activities of problem-solving skills focusing on creativity with collaboration between departments, between faculties and accommodated by universities, 3) activities that support the ability of problem-solving skills focusing on creativity are still in the process of development and are still in the validation stage by experts so there may still be further improvements from the results of this study.

Acknowledgments

At the conclusion of this research report, gratitude is expressed to the Ministry of Research, Technology and Higher Education, with special recognition to the Rector of Unimed, for the financial support that made this study possible. It is anticipated that the findings of this research will prove valuable in improving the educational experience of Unimed students and, more broadly, contribute to the improvement of the entire Unimed institution.

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Development of a digital number theory book supported by explainer videos to enhance students' critical thinking skills

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Abstract. *This research is the development of a digital Number Theory book supported by explainer videos which complies with the criteria of validity, practicality, and effectiveness of the development product. in enhancing students' critical thinking skills. The research design encompasses a series of processes, including defining, designing, developing, and disseminating. The present study was carried out inside the Mathematics Education study program at Universitas Negeri Medan. The participants of this research consisted of fourth-semester students who were currently enrolled in the Number Theory course. The research utilized several instruments, namely: 1) validation sheets; 2) expert assessment sheets assessing the practicality and effectiveness of employing the digital Number Theory book supported by explainer videos; 3) observation sheets assessing the practicality of utilizing the digital Number Theory book supported by explainer videos; 4) critical thinking skills tests provided to students; and 5) student response questionnaires. The research commences by conducting a front-end analysis, which involves examining many aspects such as student analysis, task analysis, concept analysis, and the formulation of learning objectives. Following this, the development of the research instrument, selection of media, selection of format, and initial design of the digital book on Number Theory, supported by explainer videos (prototype 1), are undertaken. The first prototype is thereafter subjected to validation, revision, and classroom trial. The validity, practicality, and effectiveness of the digital Number Theory book, along with its supporting explainer videos, are evaluated through the analysis of expert assessments and trial data. This analysis aims to determine the extent to which the developed prototype enhances students' critical thinking skills. The findings from this evaluation lead to the development of a final prototype that is deemed valid, practical, and effective.*

Keywords: Development Research, Digital Book, Explainer Videos, Critical Thinking Skills, Number Theory

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Introduction

Mathematics education has become a subject that requires special attention in teaching and learning methods. One of the topics that requires in-depth understanding is number theory. Number theory is one of the essential foundations of mathematics, strengthening the comprehension of integers, the relationships among numbers, number properties, and many other important concepts in mathematics.

In the context of higher education, the success in understanding number theory is often closely related to students' ability to apply critical thinking skills. Some students encounter difficulties in dealing with abstract and complex concepts within number theory. Therefore, an innovative learning approach is required to enhance students' understanding of number theory while reinforcing their critical thinking skills.

In an effort to meet this need, the development of a digital book with an explanatory approach through videos (explainer videos) emerges as an intriguing alternative. A digital book containing number theory content supported by explainer videos can provide clearer and more interactive visualizations of often intricate mathematical concepts.

Based on previous research, the use of explainer videos has proven effective in supporting mathematics learning in a more dynamic way. Several studies highlight the effectiveness of using explainer videos in enhancing students' understanding of mathematical concepts [2,3].

Thus, aiming to enhance students' understanding and mastery of number theory as well as strengthen critical thinking skills, this research aims to develop a digital book on number theory supported by explainer videos. This study evaluates the validity, practicality, and effectiveness of the digital number theory book supported by explainer videos in enhancing students' critical thinking skills in the field of number theory.

Methodology

This research aims to produce a digital number theory book supported by explainer videos to enhance students' critical thinking skills. The research design used consists of four stages of development, namely defining, designing, developing, and disseminating [3]. The criteria for the quality of this development product use validity, practicality, and effectiveness criteria [4].

The defining stage involves setting and defining the learning needs by analyzing the objectives and limitations of the material developed in the digital book supported by explainer videos. This includes front-end analysis, student analysis, task analysis, concept analysis, and formulating learning objectives.

The designing stage involves designing the Digital Number Theory book supported by explainer videos to obtain the format of prototype 1 (the initial prototype). This stage includes designing test instruments, selecting media, choosing formats, and the initial design of prototype 1.

The developing stage is about materializing the design of the Digital Number Theory book supported by explainer videos and the test instruments from the designing stage. This stage results in Prototype 1 of the Digital Number Theory book supported by explainer videos. Prototype 1 is then validated. The validation data is then analyzed. Based on the validation data analysis, it can be determined whether the digital book supported by explainer videos needs revision, whether it requires major or minor revisions. If a major revision is needed, Prototype 1 is revised first. The result of this major revision is Prototype 2. Prototype 2 is then validated again before proceeding

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to classroom trial I. However, if the revision process results in minor revisions, Prototype 1 is revised first. The result of this minor revision is Prototype 2. Prototype 2 is then immediately implemented in the classroom trial (classroom trial I). The purpose of classroom trial I is to obtain a practical and effective Digital Number Theory book supported by explainer videos. The data from classroom trial I is then analyzed. Based on the analysis of the classroom trial I data, it can be determined whether Prototype 2 meets the practical and effective criteria. If not, Prototype 2 needs to be revised. The result of this revision process is Prototype 3. Prototype 3 is then implemented again in classroom trial II. However, if Prototype 2 meets the practical and effective criteria, the classroom trial process is complete, and Prototype 2 is the final prototype of this development research. The cycle of validation → revision → classroom trial continues until a valid, practical, and effective Digital Number Theory book supported by explainer videos is obtained, which can enhance students' critical thinking skills.

The disseminating stage involves the dissemination of the implementation of the Digital Number Theory book supported by explainer videos in the Mathematics Education study program of UNIMED, which meets the criteria of validity, practicality, and effectiveness, initially socialized in the Mathematics Education study program through a Focus Group Discussion (FGD).

This research was conducted in the Mathematics Education study program in the even semester of the academic year 2022-2023. The subjects in this research are fourth-semester students in the Mathematics Education study program who are taking the Number Theory course. The objects in this research are a) the digital Number Theory book supported by explainer videos and b) students' critical thinking skills.

Data on the validity, practicality, and effectiveness of the Digital Number Theory book supported by explainer videos were obtained using the following instruments: 1) validation sheets; 2) expert assessment sheets on the practicality and effectiveness of using the digital Number Theory book supported by explainer videos; 3) observation sheets on the practicality of using the digital Number Theory book supported by explainer videos; 4) critical thinking skills tests for students; and 5) student response questionnaires.

Results and discussion

The developmental research product is a digital Number Theory book supported by explainer videos that meets the established quality criteria. The research data are based on the consistency of two assessment results: 1) expert assessment based on theoretical mastery and experience in assessing the validity, practicality, and effectiveness of the digital Number Theory book supported by explainer videos before its application in learning (classroom trial), and 2) assessment of the practicality and effectiveness of the digital Number Theory book supported by explainer videos during the classroom trial.

Expert assessment (before the classroom trial process)

Expert assessment data on the theoretical validity, practicality, and effectiveness of the digital Number Theory book supported by explainer videos before its application in learning (classroom trial) are presented in Table 1.

Based on Table 1 below, it can be observed that the total mean score for the validity of the developed digital Number Theory book is 4.48. If this value aligns with the established mean score for validity, it is concluded that the developed digital Number Theory book is valid. Similarly, the

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total mean score for the validity of the developed explainer video is 4.54. If this value aligns with the established mean score for validity, it is concluded that the developed explainer video is valid.

The total mean score for the implementation of learning using the digital Number Theory book supported by explainer videos is 4.43. If this value aligns with the established mean score for the practicality of using the digital Number Theory book supported by explainer videos, it is concluded that the practicality of using the developed digital Number Theory book supported by explainer videos is high.

Table 1. The expert asessment

Assessment Objects	Aspects	Average Score	Total Average Score
Validity of Digital Number Theory Book	a. Format	a. 4.40	
	b. Language	b. 4.48	4.48
	c. Content	c. 4.57	
Validity of Explainer Video	a. Format	a. 4.53	
	b. Language	b. 4.48	4.54
	c. Content	c. 4.62	
Assessment of the Implementation of Learning	a. Syntax	a. 4.42	
	b. Social System	b. 4.47	4.43
	c. Principles of Reaction and Management	c. 4.40	
Assessment of the Effectiveness of Learning Materials	a. Students' Learning Outcomes	a. 4.42	
	b. Time Alloaction	b. 4.33	4.44
	c. Support for the Achievement of Students' Responses	c. 4.56	

The total mean score for the effectiveness of learning using the digital Number Theory book supported by explainer videos is 4.44. If this value aligns with the established mean score for the effectiveness of using the digital Number Theory book supported by explainer videos, it is concluded that the effectiveness of using the developed digital Number Theory book supported by explainer videos is high.

Classroom trial data

Data on the assessment of the practicality and effectiveness of using the digital Number Theory book supported by explainer videos in the class trial are presented in the following Table 2.

Table 2. Classroom trial data

Assessment Objects	Aspects	1st Trial		2nd Trial	
Assessment of the Implementation of Learning	a. Syntax	a. 4.20		a. 4.58	
	b. Social System	b. 4.07		b. 4.47	
	c. Principles of Reaction and Management	c. 4.40		c. 4.67	
	Total Mean Score	4.42		4.57	
		Pre	Post	Pre	Post
Assessment of the Effectiveness of Learning Materials	Students' Critical Thinking Skills	55.82	63.01	56.59	72.26
	Students' Respond	75.26%		82.48%	

Based on Table 2, it can be observed that the average score for the implementation of learning using the digital Number Theory book supported by explainer videos in classroom trial 1,

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regarding the syntax aspect, is 4.20, the social system aspect is 4.07, and the principles of reaction and management aspect is 4.40. The total average score for the implementation of learning using the digital Number Theory book supported by explainer videos in classroom trial 1 is 4.42. If this value aligns with the established mean score for the practicality of using the digital Number Theory book supported by explainer videos, it is concluded that the practicality of using the developed digital Number Theory book supported by explainer videos in classroom trial 1 is high. Similarly, in classroom trial 2, the total average score for the implementation of learning using the digital Number Theory book supported by explainer videos is 4.57. If this value aligns with the established mean score for the practicality of using the digital Number Theory book supported by explainer videos, it is concluded that the practicality of using the developed digital Number Theory book supported by explainer videos in classroom trial 2 is high.

The average score for students' critical thinking skills after classroom trial 1 is 63.01. If this average score for students' critical thinking skills aligns with the established criteria, it can be concluded that students' critical thinking skills are at a low level. This indicates that the average score for students' critical thinking skills after classroom trial 1 has not yet reached the set target. In contrast, the average score for students' critical thinking skills after classroom trial 2 is 72.26. If this average score for students' critical thinking skills aligns with the established criteria, it is concluded that students' critical thinking skills are at a moderate level and have reached the set target.

The average score for students' responses after classroom trial 1 is 75.26%. This means that the percentage of students who responded positively to the implementation of learning using the developed digital Number Theory book supported by explainer videos is 75.26%. If this average score for students' responses aligns with the established target, it is concluded that the percentage of students who responded positively to the implementation of learning in classroom trial 1 using the developed digital Number Theory book supported by explainer videos has not yet reached the target, which is a minimum of 80%. In contrast, the average score for students' responses after classroom trial 2 is 82.48%. This means that the percentage of students who responded positively to the implementation of learning in classroom trial 2 using the developed digital Number Theory book supported by explainer videos has reached the target after classroom trial 2.

After classroom trial 1 was completed, the researcher made improvements to the developed digital Number Theory book supported by explainer videos. The improvements were made in the explainer videos, where the researcher not only developed explainer videos containing explanations of the learning content but also added illustrations that correspond to the material explained in the explainer videos. Subsequently, the improved digital Number Theory book supported by explainer videos was applied in classroom trial 2. Based on the aforementioned research data, it can be concluded that the developed digital Number Theory book supported by explainer videos has met the criteria for validity, practicality, and effectiveness.

The use of digital media, such as digital books and explainer videos, has proven to be an effective tool in mathematics education. According to Hake, using a variety of media in learning, such as videos and computers, can strengthen understanding of mathematical concepts and problem-solving skills [5]. Using explainer videos can help develop critical thinking skills. According to Mayer, videos can facilitate a better understanding of concepts and help students link information, thereby enhancing critical thinking skills [6]. The findings of this research are also consistent with the study by Panjaitan et al., where mathematics learning using digital books

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supported by explainer videos is one of the alternatives to enhance students' critical thinking skills [7].

Utilizing digital books has piqued the interest of students in learning. According to Clark & Mayer, digital books supported by visualizations, animations, and interactive explanations can enhance students' understanding of the material [8]. The combination of digital books with explainer videos can yield better results in mathematics education. According to Peña-Ayala, this approach can enhance problem-solving skills and help students connect difficult concepts [9].

Conclusion

The product of this developmental research is a valid, practical, and effective digital Number Theory book supported by explainer videos. The use of this digital Number Theory book supported by explainer videos significantly contributes to improving students' critical thinking skills. Integrating digital media in mathematics education provides students with the opportunity to better understand complex concepts and develop the critical thinking skills necessary to solve mathematical problems.

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Development of Integral Calculus Book Based on Problem-Based Learning Model Oriented to HOTS

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Abstract. *This research is the development of an Integral Calculus book based on a Problem-Based Learning Model oriented to HOTS that is valid, practical, and effective in enhancing students' higher order thinking skills. The research design used is the 4-D development design, which consists of the define, design, develop, and disseminate stages. This research was conducted in the mathematics education program with research subjects being second-semester students currently enrolled in the Integral Calculus course. To obtain data on the validity of the research product, three experts were provided with validation sheets to assess the validity of the book, student worksheets, and test instruments developed. For practicality data, assessment sheets (before classroom trials) and observation sheets (during classroom trials) were utilized to evaluate the implementation of learning using the integral calculus book based on a problem-based learning model oriented towards HOTS. To gather data on effectiveness, assessment sheets for the effectiveness of learning using the developed integral calculus book (before classroom trials), as well as high-order thinking skill tests and student response questionnaires (during classroom trials), were employed. This research begins with front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives. Subsequently, research instrument design, media selection, format selection, and initial design of the Integral Calculus book based on a Problem-Based Learning Model oriented to HOTS (prototype 1) are carried out. Prototype 1 is then validated, revised, and tested. Data analysis of expert assessments and classroom trial data is conducted to determine the validity, practicality, and effectiveness of the developed Integral Calculus book based on a Problem-Based Learning Model oriented to HOTS, resulting in a final prototype that is valid, practical, and effective in enhancing students' higher order thinking skills.*

Keywords: Development Research, Textbooks, Problem-Based Learning Model, HOTS, Integral Calculus

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Introduction

Learning integral calculus is an important topic in mathematics education. In the context of mathematical learning, the focus on Higher Order Thinking Skills (HOTS) has become a primary concern for developing analytical skills, problem-solving, and critical thinking among students. In the effort to enhance the understanding and application of integral calculus, the development of a book as a learning resource oriented towards HOTS is essential.

The importance of strengthening the understanding of integral calculus lies not only in mastering the basic concepts but also in students' ability to apply and relate these concepts to solve real-life problems. Problem-based learning models have proven to be an effective approach to facilitating a deep understanding and utilization of integral calculus in diverse contexts.

According to Misra & Agarwal, problem-centered integral calculus instruction has shown a significant increase in student motivation and mastery of concepts [1]. Meanwhile, Schoenfeld outlines theories in the literature that emphasize the significance of using pertinent and challenging problem contexts when teaching calculus [2].

This research aims to develop a book on integral calculus that not only facilitates conceptual understanding but also integrates an HOTS-oriented approach through problem-solving. The development of the book has the potential to have a substantial impact on the improvement of students' abilities in critical and analytical thinking, specifically in comprehending and utilizing integral calculus.

By establishing a solid groundwork for the development of an integral calculus textbook, this research aims to contribute to the enhancement of mathematics education by focusing on the utilization of HOTS in the resolution of problems.

Methodology

The product of this developmental research is an integral calculus book based on a problem-based learning model oriented towards Higher Order Thinking Skills (HOTS). The developmental stages involved consist of the stages of definition, design, development, and dissemination [3]. The criteria used to indicate that the integral calculus book based on the problem-based learning model oriented towards HOTS exhibits good quality are assessed based on validity, practicality, and effectiveness [4].

This study was conducted in the even semester of the academic year 2022-2023 in the mathematics education program, where the research subjects were second-semester students enrolled in Integral Calculus courses. The focus of this research was the integral calculus book based on a problem-based learning model oriented towards HOTS, meeting the criteria of validity, practicality, and effectiveness.

To obtain data on the validity of the research product, three experts were provided with validation sheets to assess the validity of the book, student worksheets, and test instruments developed. For practicality data, assessment sheets (before classroom trials) and observation sheets (during classroom trials) were utilized to evaluate the implementation of learning using the integral calculus book based on a problem-based learning model oriented towards HOTS. To gather data on effectiveness, assessment sheets for the effectiveness of learning using the developed integral calculus book (before classroom trials), as well as high-order thinking skill tests and student response questionnaires (during classroom trials), were employed.

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Results and Discussion

The research data is divided into two parts, namely 1) expert assessment data based on their theoretical expertise and experience to evaluate the validity, practicality, and effectiveness of the integral calculus book based on a problem-based learning model oriented towards HOTS before its implementation in the classroom trial, and 2) assessment data regarding the practicality and effectiveness of the integral calculus book based on a problem-based learning model oriented towards HOTS during the conducted classroom trial.

The Expert Assessment Data

The data in Table 1 comes from assessments made by experts based on theoretical assessments of the integral calculus book's validity, practicality, and effectiveness based on a problem-based learning model oriented towards HOTS before the classroom trial.

Table 1. The Experts Asessments

Assessment Objects	Aspects	Average Score	Total Average Score
Validity of Integral Calculus book based on a PBL Model oriented to HOTS	a. Format b. Language c. Content	a. 4.53 b. 4.62 c. 4.67	4.61
Validity of Students' Worksheet	a. Format b. Language c. Content	a. 4.60 b. 4.52 c. 4.57	4.57
Validity of HOTS Test	a. Format b. Language c. Content	a. 4.47 b. 4.43 c. 4.48	4.46
Practicality of Learning Theoretically	a. Syntax b. Social System c. Principles of Reaction and Management	a. 4.47 b. 4.53 c. 4.40	4.47
Effectiveness of Learning Theoretically	a. Students' Learning Outcomes b. Time Alloaction c. Sudents' Respond	a. 4.50 b. 4.44 c. 4.67	4.54

Based on Table 1, it can be observed that the total mean score for the validity of the developed integral calculus book based on a problem-based learning model oriented towards HOTS is 4.61. Referring to the established total mean score for validity, it is concluded that the developed integral calculus book based on a problem-based learning model oriented towards HOTS is valid. Similarly, the total mean scores for the validity of student worksheets and the HOTS test developed are 4.57 and 4.46, respectively, meeting the validity criteria.

The total mean score for the practicality of using the developed integral calculus book based on a problem-based learning model oriented towards HOTS is 4.47. This score is then compared to the established total mean score for practicality, leading to the conclusion that the practicality of using the developed integral calculus book based on a problem-based learning model oriented towards HOTS is high.

Moreover, the total mean score for the effectiveness of using the developed integral calculus book based on a problem-based learning model oriented towards HOTS is 4.54. This score is compared to the established total mean score for effectiveness, leading to the conclusion that the

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effectiveness of using the developed integral calculus book based on a problem-based learning model oriented towards HOTS is high.

The Classroom Trial Data

The research data presented in Table 2 is the assessment data on the practicality and effectiveness of learning using the integral calculus book based on a problem-based learning model oriented towards HOTS during the classroom trial.

Table 2. The Classroom Trial Data

Assessment Objects	Aspects	Trial I		Trial II	
Practicality of Learning in Classroom Trials	a. Syntax	a. 4.31		a. 4.47	
	b. Social System	b. 4.13		b. 4.40	
	c. Principles of Reaction and Management	c. 4.53		c. 4.60	
	Rerata Toal	4.33		4.49	
		Pre	Post	Pre	Post
Effectiveness of Learning in Classroom Trials	Students' Critical Thinking Skills	53.70	60.89	55.47	71.14
	Students' Respond	76.00%		84.20%	

Based on Table 2, it is evident that the average practicality scores of learning using the integral calculus book based on a problem-based learning model oriented towards HOTS in classroom trial 1 were 4.31 in the syntax aspect, 4.13 in the social system aspect, and 4.53 in the principles of reaction and management aspect. The total mean score for the practicality of teaching using the developed integral calculus book in classroom trial 1 was 4.33, which, upon reference to the set total mean score for practicality, concluded that the practicality of using the developed book in classroom trial 1 was high. Similarly, in classroom trial 2, the total mean score for the practicality of learning using the developed integral calculus book based on a problem-based learning model oriented towards HOTS was 4.49. Upon comparison with the established total mean score for practicality, it was concluded that the practicality of teaching using the developed book in classroom trial 2 was high.

The average score of students' higher-order thinking skills after classroom trial 1 was 60.89. After referencing the criteria, it was concluded that the students' higher-order thinking skills were in the low criteria and had not yet reached the set target. In contrast, the average score of students' higher-order thinking skills after classroom trial 2 was 71.14. Upon reference to the criteria, it was concluded that the students' higher-order thinking skills were in the moderate criteria and had reached the set target.

The average score of student response after classroom trial 1 was 76.00%. This means that 76.00% of students responded positively to the implementation of teaching using the developed integral calculus book based on a problem-based learning model oriented towards HOTS. Upon referencing the set target, it was concluded that the percentage of students responding positively in classroom trial 1 using the developed book had not yet reached the target of at least 80%. On the other hand, the average score of student response after classroom trial 2 was 84.20%. This indicates that the percentage of students responding positively in classroom trial 2 using the developed book had reached the target after the trial was conducted.

After the completion of classroom trial 1, the researcher made improvements to the developed integral calculus book based on a problem-based learning model oriented towards HOTS. The improvements were made in the problems presented in the book, not only as complex problems

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but also included steps, instructions, or illustrations to help students solve complex problems. Additionally, the problems were clarified to highlight the HOTS aspects to be achieved, such as analyzing, examining, and discovering new concepts and principles. The improved book was then implemented in classroom trial 2, which was conducted in a different class from classroom trial 1. The preceding discussion outlined the research data in classroom trial 2, concluding that the developed integral calculus book met the criteria of validity, practicality, and effectiveness.

Research on the development of an integral calculus book based on a problem-based learning model indicates that this model has the potential to enhance students' understanding of integral calculus. By integrating authentic problems relevant to everyday life, students are given the opportunity to discover and apply integral calculus concepts in real-world contexts. This is supported by research that states that problem-based learning strengthens the application of mathematical concepts and deepens student understanding [5].

Problem-based learning has also been proven to promote the development of Higher Order Thinking Skills (HOTS) among students. By solving problems that require in-depth analysis and the application of concepts, students become skilled in critical and creative thinking. Theories emphasizing the importance of HOTS in education, such as those proposed by Anderson & Krathwohl, affirm that learning to foster HOTS has a positive impact on students' intellectual development [6]. However, in implementing problem-based learning in integral calculus, there are challenges to overcome. One of these is the lack of time to solve complex problems, as mentioned by Stewart, who states that calculus learning is often restricted by a dense curriculum [7].

The use of an integral calculus book based on a problem-based learning model oriented towards HOTS provides an advantage in empowering students to think independently, develop strong analytical skills, and establish connections between mathematical concepts and the real world. However, there is a need for instructional materials that are more adaptable to students' needs and a more flexible time schedule to enable students to explore more complex mathematical problems.

Conclusion

The product of this developmental research is an integral calculus book based on a problem-oriented learning model, focused on HOTS, which has met the criteria for validity, practicality, and effectiveness. In its implementation, it can enhance students' higher-order thinking skills.

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Development of a digital integral calculus book assisted by animation videos to enhance students' critical thinking skills

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Abstract. *Textbooks and learning media serve as supplementary tools that facilitate the construction of mathematical knowledge among students. In order for students to achieve the intended learning outcomes, critical thinking skills are an essential 21st-century competency that they must possess throughout this construction process. The inadequate level of critical thinking exhibited by students enrolled in Integral Calculus courses has motivated scholars to create a technologically integrated digital integral calculus textbook. This textbook enables students to access abstract mathematical concepts in a timely and location-independent manner, both individually and in groups. The objective of this study is to create an animation video-assisted digital integral calculus textbook that is in accordance with the established quality criteria in augmenting students' critical thinking abilities. The development design, comprising the phases of defining, designing, developing, and disseminating, was employed as the research framework, was employed as the research framework. The present study was carried out within the mathematics education program, utilizing second-semester students who were enrolled in the integral calculus course as research subjects. The study included the following instruments: 1) validation sheets; 2) expert assessment sheets concerning the practicality and effectiveness of utilizing the digital integral calculus book augmented with animation videos; 3) observation sheets examining the practicality of utilizing the aforementioned resource; 4) assessments of students' critical thinking abilities; and 5) student response questionnaires. The present study commences with preliminary and concluding analyses, followed by student evaluations, task and concept assessments, and the development of learning objectives. Following this, the process of developing the research instrument design, selecting media and formats, and creating the initial design of the digital integral calculus book with the aid of animation videos (prototype 1) is initiated. Following this, Prototype 1 is revised, validated, and tested. To ascertain the validity, practicality, and effectiveness of the digital integral calculus book that has been developed with the assistance of animation videos, an examination is carried out on trial data and expert evaluations. The outcome is a definitive prototype that satisfies the criteria of being valid, practical, and effective in augmenting students' critical thinking abilities.*

Keywords: Development Research, Digital Book, Animation Videos, Critical Thinking Skills, Integral Calculus

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Introduction

In the present era, technological advancements have become key to the transformation of education, particularly in teaching and learning methods. One field continually advancing is mathematics education, where Integral Calculus stands as a subject that demands a deep understanding but is often challenging for students due to its level of abstraction and complexity. Critical thinking skills are essential in mastering Integral Calculus, enabling students to analyze, interpret, and solve problems involving these mathematical concepts.

In an effort to enhance the effectiveness of teaching Integral Calculus and students' comprehension, the utilization of technology takes center stage. Developing digital books supported by animation videos presents an intriguing alternative to improve the traditional approach to teaching this subject. The use of interactive digital books with visualizations through animation videos can aid in explaining complex concepts in a more engaging and understandable manner.

Several studies have highlighted the importance of critical thinking skills in mathematical learning, especially in Integral Calculus. For instance, Smith and Ferguson found that the use of video and animation could enhance subject understanding in higher education [1]. Rasmussen and Ellis revealed that animation supports dynamic mathematical learning [2]. Within this framework, the use of digital books supported by animation becomes a promising breakthrough in facilitating the Integral Calculus learning process.

This research aims to explore the impact of using digital Integral Calculus books with the assistance of animation videos on improving students' critical thinking skills. The primary focus of this research is to identify the extent to which these digital books can enhance critical thinking skills in the context of learning Integral Calculus.

Moreover, the research will involve an analysis of the effectiveness of digital books in improving the understanding of Integral Calculus material and students' ability to relate mathematical concepts to real-world situations. This aligns with Halpern's findings, emphasizing the importance of critical thinking skills in understanding and applying knowledge [3].

Methodology

This development study utilizes a development design, consisting of four developmental stages: defining, designing, developing, and disseminating [11]. The quality of the product resulting from this developmental research is based on quality criteria [12], namely valid, practical, and effective. The product of this developmental research is a digital integral calculus book assisted by animation videos aimed at enhancing students' critical thinking skills. Consequently, the goal of this developmental research is to create a digital integral calculus book assisted by animation videos that is valid, practical, and effective in improving students' critical thinking skills.

The present study was carried out within the context of the mathematics education program, focusing on a sample of second-semester students who were currently enrolled in the integral calculus course. The instruments used in this research include: 1) validation sheets; 2) expert assessment sheets on the practicality and effectiveness of using the digital integral calculus book assisted by animation videos; 3) observation sheets on the practicality of using the digital integral calculus book assisted by animation videos; 4) critical thinking skills tests for students; and 5) student response questionnaires.

The assessment of the validity aspect of the digital integral calculus book, which is supported by animation videos, is conducted by evaluating its format, language, and content. Three criteria serve as the basis for evaluating the digital integral calculus book's practicality. Syntax, which

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describes the learning process using the digital integral calculus book assisted by animation videos. Social system, which describes the interactions occurring in the learning process using the digital integral calculus book assisted by animation videos. This includes interactions between students, students and instructors, and interactions among students within the learning environment. Principles of reaction and management, which describe the role of instructors in responding to student behavior during the learning process using the digital integral calculus book assisted by animation videos. The evaluation of the practicality of learning using the digital integral calculus book assisted by animation videos is based on the consistency of two assessments: 1) theoretical assessment by experts based on theoretical mastery and experience, referred to as Intended↔Perceived (IP), and 2) assessment based on classroom trials, referred to as Intended↔Operational (IO). The effectiveness aspect of the digital integral calculus book assisted by animation videos is assessed based on the consistency of two assessments: 1) evaluation by experts before the implementation of the digital integral calculus book assisted by animation videos in the classroom, referred to as Intended↔Experiential (IE), and 2) achievement of effectiveness indicators/ aspects defined during classroom trials, referred to as Intended↔Attained (IA). The aspects evaluated in the effectiveness of learning using the digital integral calculus book assisted by animation videos include assessment of: 1) students' learning outcomes, which involve the average score of students' critical thinking skills; 2) time allocation; and 3) the attainment of students' responses [13].

The research commences by doing front-end analysis, student analysis, task analysis, concept analysis, and the formulation of learning objectives. Subsequently, research instrument design, media selection, format selection, and initial design of the digital integral calculus book assisted by animation videos (prototype 1) are carried out. Prototype 1 is then validated, revised, and tested. Data analysis of expert assessments and trial data is conducted to determine the validity, practicality, and effectiveness of the developed digital integral calculus book assisted by animation videos, resulting in a final prototype that is valid, practical, and effective in enhancing students' critical thinking skills.

Results and discussion

The research data is presented in two parts: 1) data concerning expert assessment before the trial process, and 2) data from classroom trials assessing the validity, practicality, and effectiveness of the digital integral calculus book assisted by animation videos.

Expert assessment

Validation activities were carried out by three experts (lecturers at the Mathematics Department of UNIMED) who had experience in development research before the trials were carried out. The activities carried out are (1) validation of the digital integral calculus book and animation videos and (2) assessment of the implementation and effectiveness of learning by using the digital integral calculus book assisted by animation videos by experts based on their mastery of theory and experience. Based on the results of the assessments of these experts, the data is obtained in Table 1.

Based on the validity (Va) score of the digital integral calculus book assisted by animation videos in Table 1, it can be concluded that the validity of the developed digital integral calculus book and animation videos meets the valid criteria. In addition, based on the IP and IE scores in Table 2, it is concluded that the level of practicality and effectiveness of learning by using a digital integral calculus book assisted by animation videos is a high criterion. Since the level of

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validity of the digital integral calculus book and animation videos, as well as the level of implementation and effectiveness of learning by using the digital integral calculus book assisted by animation videos assessed by experts based on their mastery of theory and experience, have met the set targets, the digital integral calculus book assisted by animation videos developed were then implemented in the Integral Calculus course.

Table 1. The experts asessments

Assessment Objects	Aspects	Total Average	Score
Validity of Digital Integral Calculus Book	a. Format b. Language c. Content	a. 4.73 b. 4.67 c. 4.71	Va = 4.70
Validity of Animation Video	a. Format b. Language c. Content	a. 4.80 b. 4.62 c. 4.67	Va = 4.70
Assessment of the Implementation of Learning (IP)	a. Syntax b. Social System c. Principles of Reaction and Management	a. 4.60 b. 4.67 c. 4.53	IP = 4.60
Assessment of the Effectiveness of Learning Materials (IE)	a. Students' Learning Outcomes b. Time Alloaction c. Support for the Achievement of Sudents' Responses	a. 4.58 b. 4.56 c. 4.56	IE = 4.56

The trials of digital integral calculus book assisted by animation videos

After the activities (1) validation of the digital integral calculus book and animation videos and (2) assessment of the implementation and effectiveness of learning by using the digital integral calculus book assisted by animation videos by experts based on their mastery of theory and experience, the next activity is a trial of the digital integral calculus book assisted by animation videos in the Integral Calculus course. The data from the trial results are presented in Table 2.

Table 2. Classroom trial data

Assessment Objects	1st Trial		2nd Trial	
Assessment of the Implementation of Learning (IO)	IO = 4.47		IO = 4.62	
Students' Critical Thinking Skills (IA_1)	Pre	Post	Pre	Post
	55.00	62.19	55.60	71.27
Students' Respond (IA_2)	72.60%		85.12%	

Based on the IO values in Table 2, it is concluded that the practicality of learning by using a digital integral calculus book assisted by animation videos based on trial data meets the high criteria in the first trial. However, the average score of students' critical thinking skills in the first trial was 62.19, which is still below the low criteria. In addition, the student response in the first trial was quite satisfactory; as many as 75.80% of students responded positively to the developed digital integral calculus book assisted by animation videos. Based on the advice from the assessment team, the researchers made improvements to the animation videos so that the information presented is more detailed and comprehensive. After the revision process is carried out, the trial further phase of the digital integral calculus book assisted by animation videos is continued to the trial phase II.

Based on table 2, it can be seen that the IO scores, students' critical thinking skills scores, and student responses in the second trial have met the set targets. It means that in the second trial, the valid, practical, and effective digital integral calculus book assisted by animation videos has been

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composed to improve students' thinking skills in Integral Calculus course. However, further study still needs to be done so that students' thinking skills can be optimally improved from the results obtained in this study.

The results of this study indicate that the digital integral calculus book assisted by animation videos developed meets the criteria for good learning as a supporting system of learning to achieve the expected learning goals and enable students to master particular competencies [4-6]. This digital integral calculus book assisted by animation videos helps the students carry out the abstraction process because abstract mathematical objects become real and makes it easier for students to carry out the process of problem identification, exploration, reflection, and presentation of learning results [7-8]. Therefore, the use of a digital integral calculus book assisted by animation videos makes it easier for students to construct or rediscover abstract mathematical knowledge [9]. Students find it easier to interpret the context of the proposed problem, carry out the analysis process, solve the proposed problem, and explain the related aspects easier [10].

Conclusion

The results of this study indicate that the use of a digital integral calculus book assisted by animation videos is an alternative to improve students' critical thinking skills in the learning process. The digital integral calculus book assisted by animation videos makes it easier for students to construct abstract mathematical knowledge. However, further study needs to be conducted so that the improvement of students' critical thinking skills can be more optimal based on the results of this study.

Acknowledgments

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Career Prediction of Undergraduate Alumni Using Fuzzy Logic

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Abstract. *One of the 8 Main Performance Indicators of Higher Education is that graduates get decent jobs. This indicator is fulfilled by the number of alumni who succeed in getting a decent job (salary above the minimum wage), continuing their studies or becoming self-employed. A graduate has three major choices in starting his career in the world of work, namely working in a company, continuing his studies, or becoming self-employed. The decision in choosing a career is certainly influenced by the experience that has been passed during the lecture. This study was conducted to predict career choice decisions by Medan State University undergraduate program alumni. The factors or alumni experiences chosen by researchers as input variables are GPA, achievement, organizational activity, work intensity and TOEFL scores. The method used is the Mamdani method. Alumni data was obtained from a questionnaire to 100 respondents who are undergraduate alumni of Medan State University in 2021 and 2022. The GPA variable is divided into 2 fuzzy sets, namely Low and High. The achievement variable is divided into 2 fuzzy sets, namely Few and Many. The organizational activity variable is divided into 2 fuzzy sets, namely Less and Active. The work intensity variable is divided into 2 fuzzy sets, namely Occasionally and Always. While the TOEFL score variable is divided into 3 fuzzy sets, namely Low, Medium and High. For the output variable, namely career, it is divided into 2 fuzzy sets, namely Working and Continuing Studies. Researchers formed 48 rules used in determining alumni career predictions as system output. To facilitate system testing, researchers use the MATLAB application. Based on system testing, prediction accuracy is categorized as Good with a MAPE value of 14.6%.*

Keywords: Key Performance Indicators, Alumni career, fuzzy, Mamdani, MAPE

Introduction

The measure of an advanced university is to fulfill 8 Key Performance Indicators (KPIs). One of the 8 KPIs is that graduates get decent jobs. This indicator is fulfilled judging by the number of alumni who succeed in getting a decent job, continuing their studies or becoming self-employed [1]. To achieve this, of course, various efforts are needed. Law No. 12 of 2021 states that improving the quality of university graduates can be done by encouraging students to not only follow learning in the classroom, but also actively develop themselves through co-curricular and extracurricular activities.

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A graduate has three major choices in starting his career in the world of work, namely working in a company, continuing his studies, or becoming self-employed. The decision in choosing this career is certainly influenced by the experience that has been passed during the lecture. Research to look at the factors of the waiting period for alumni to start working has been done a lot. Organizational activity, main source of tuition fees, ability to compete with other graduates, study period, competencies mastered, GPA, gender and continuing are factors that affect the waiting period for work [2]. Alumni who have worked while in college have a very low waiting period for work.

Some undergraduate alumni choose not to work immediately, but choose to continue their master's studies. For alumni who have economic limitations, obtaining a scholarship is certainly a solution. GPA, achievement and English language skills are the most important factors to obtain a scholarship. To obtain an LPDP Regular scholarship, prospective applicants must have a minimum GPA of 3.00, TOEFL ITP score of 500 for Domestic programs and TOEFL iBT 80 [3].

The career choice of becoming an entrepreneur is often seen as a choice that is avoided. A career as an entrepreneur is not something special for the younger generation, especially among academics [4]. A career as an entrepreneur is an unfavorable choice because it has to deal with daily uncertainty, obstacles, and frustrations related to the process of establishing a new business [5].

Decision Support System (SPK) is a system that can help make decisions to solve semi-structured problems, support assessment and improve the effectiveness of management decision making [6]. To produce an appropriate Decision Support System, the selection of methods must be considered. One method that can be used is fuzzy logic. Fuzzy logic is very flexible, meaning that it is able to adapt to changes and uncertainties that accompany problems and has tolerance for imprecise data and has the ability to handle data.

Several methods can be used in fuzzy logic, one of which is the Mamdani Method. The Mamdani method, otherwise called the Min-Max method is the simplest and most frequently used method [7]. In the Decision Making System, the Mamdani method is more recommended in determining decisions because the calculation results are closer to the actual results compared to other methods [8].

Methodology

This research uses a quantitative approach with alumni profiles and career choices. To obtain quality research results, researchers compiled research procedures, namely 1) data collection, 2) data analysis, 3) system development and implementation, 4) system testing, and 5) conclusion drawing.

The research uses primary data obtained through a questionnaire conducted online to Medan State University undergraduate alumni in 2021 and 2022. The collected data is analyzed to form data groups that will be used in the system. Based on the data groups formed, researchers develop and implement the system. This research uses the Mamdani method with four stages, namely defining input and output variables and converting them into fuzzy sets, creating fuzzy rules, rule composition and defuzzification. To facilitate the process of implementing and testing the system, the entire calculation process uses the help of MATLAB. To measure the accuracy of data forecasting, researchers use the Mean Absolute Percentage Error (MAPE) indicator.

Mamdani method

The Mamdani method (min-max method) was popularized by Ebrahim Mamdani in 1975. This method is a very flexible method and has tolerance for existing data. Therefore, the Mamdani method is suitable for processing input data that comes from humans [9]. The

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Mamdani method uses the Min function as an implication function and the Max method as a rule composition method. At the defuzzification stage using the centroid method.

Mean absolute percentage error (MAPE)

MAPE is an indicator to validate the accuracy of forecasting results. To calculate MAPE, the following equation is used:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|Y(t) - Y'(t)|}{Y(t)} \times 100\%$$

With $Y(t)$ is the actual data, $Y'(t)$ is the forecasting value and n is the amount of data used [10].

MAPE accuracy criteria can be seen in Table 1 below

Table 1. MAPE accuracy criteria

Criteria	MAPE Percentage Limit
Very good	< 10%
Good	10% - 20%
Simply	20% - 50%
Inaccurate	>50%

Result and discussion

Data collection

The population in this study were alumni of Medan State University in 2021 and 2022. The total population obtained from the Career and Entrepreneurship Development Unit (UPKK) of Medan State University is 7481 graduates consisting of 3699 graduates in 2021 and 3782 graduates in 2022. The number of samples uses the Slovin equation calculation with a 90% confidence interval and a 10% error estimate. Based on the calculation, a sample size of 100 was obtained. Data on alumni profiles based on the experience gained by alumni based on respondents' answers can be seen in Table 2 and Figure 1 below

Table 2. Alumni profile data

Experience	Min	Max	Average
GPA	3,08	3,87	3,48
Many achievements	0	10	2,32
Organizational activity	1	5	3,25
Work Intensity	1	5	2,56
TOEFL Score	337	560	456,94

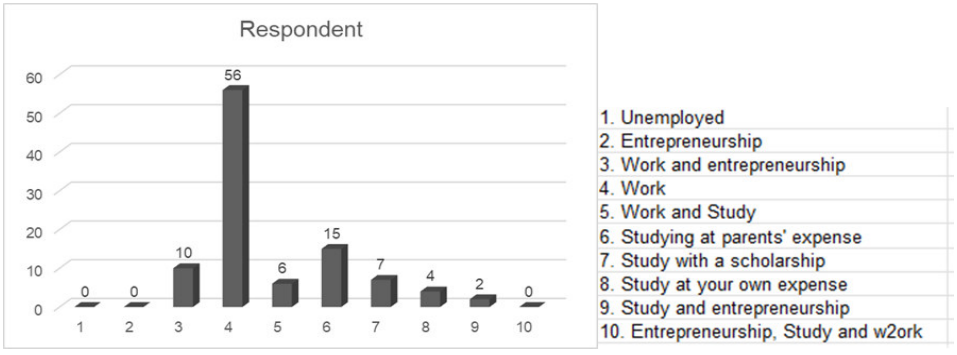

Figure 1. Alumni career

Figure 1 shows the careers that are being undertaken by alumni. Researchers set 10 careers that can be chosen by respondents. From Figure 1 it can be seen that there are no respondents who choose a career only in entrepreneurship, but entrepreneurship is undertaken

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with other careers such as work and entrepreneurship, further study and entrepreneurship. The most common career collected from the questionnaire is working with a percentage of 56%, followed by continuing studies at the expense of parents at 15%.

Fuzzy set formation

In this study, researchers took five input variables and one output variable. Each variable is formed fuzzy set as follows

1) The GPA variable is divided into two fuzzy sets, namely LOW and HIGH. The LOW fuzzy set has the domain in the interval [2,3.25] and HIGH has the domain in the interval [3.2,4].
2) The achievement variable is divided into two fuzzy sets, namely LITTLE and LOTS. The LITTLE fuzzy set has a domain in the interval [0,5] and LOTS has a domain in the interval [4,10].
3) The organizational activeness variable is divided into two fuzzy sets, namely LACK and ACTIVE. The LACK fuzzy set has the domain in the interval [1,4] and ACTIVE has the domain in the interval [3,5].
4) The Work Intensity variable is divided into two fuzzy sets, namely ONCE and ALWAYS. The ONCE fuzzy set has the domain in the interval [1,4] and ALWAYS has the domain in the interval [3,5].
5) The TOEFL Score variable is divided into three fuzzy sets namely LOW, MEDIUM, and HIGH. The LOW fuzzy set has a domain of [310,430], MEDIUM has a domain in the interval [425,485], and the HIGH fuzzy set has a domain in the interval [480,677].
6) The Career variable is divided into two fuzzy sets, namely WORK and CONTINUE STUDY. The fuzzy set WORK has a domain in the interval [2,6] and CONTINUESTUDY has a domain in the interval [4,10].

Variable membership degree function representation

In this study, researchers used two types of curves, namely triangular curves and trapezium curves to represent the membership degree function of each fuzzy set.

1) GPA Variable

   To represent the membership degree function of the LOW and HIGH fuzzy sets, a trapezium curve is used. Figure 2 below is a representation for the GPA variable.

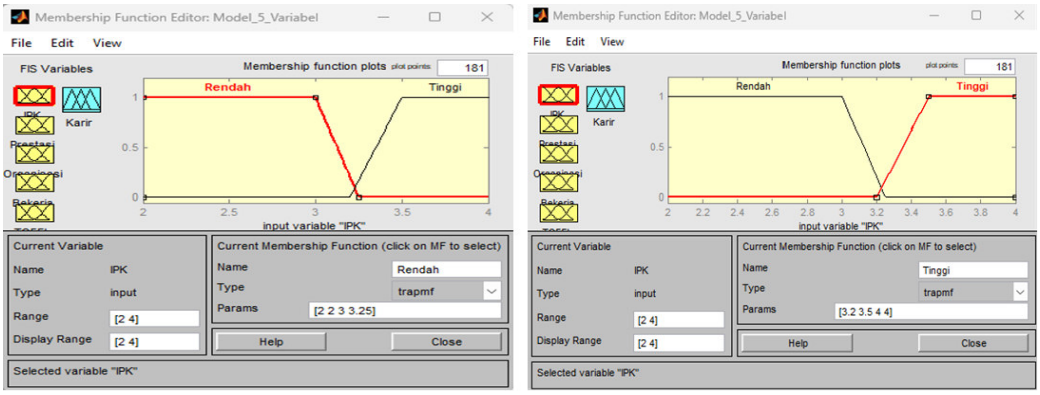

Figure 2. Representation view of GPA variable membership function

2) Achievement Variable

   The membership degree function of the LITTLE and MANY fuzzy sets in the achievement variable is represented with a trapezium curve. The representation for the Achievement variable can be seen in Figure 3 below

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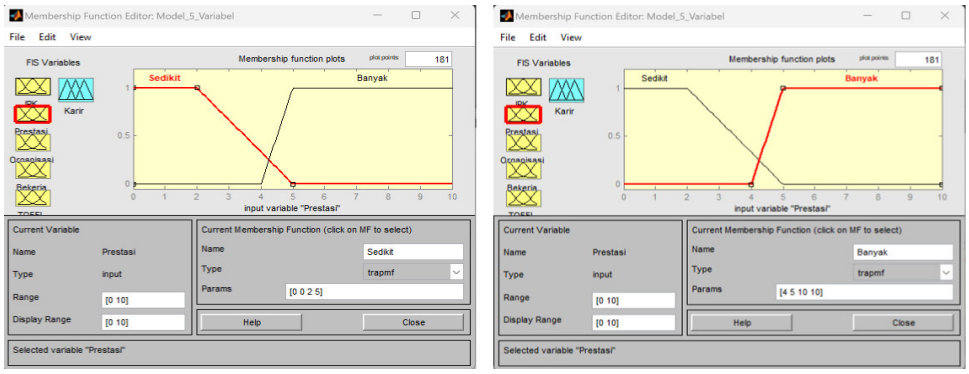

Figure 3. Representation view of the achievement variable membership function

3) Organizational Activity Variable

In the organizational activeness variable, the representation of the membership degree function of the LACK and ACTIVE fuzzy set with a trapezium curve. The representation for the membership degree function of the organizational activeness variable can be seen in Figure 4 below

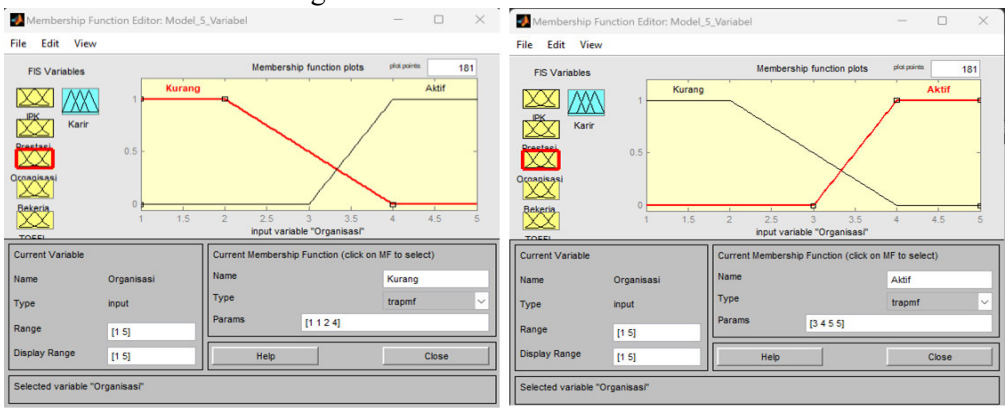

Figure 4. Display of representation of membership function of organizational activity variable

4) Work Intensity Variable

To represent the membership degree function of the ONCE and ALWAYS fuzzy set, a trapezium curve is used. Figure 5 below is a representation for the work intensity variable function.

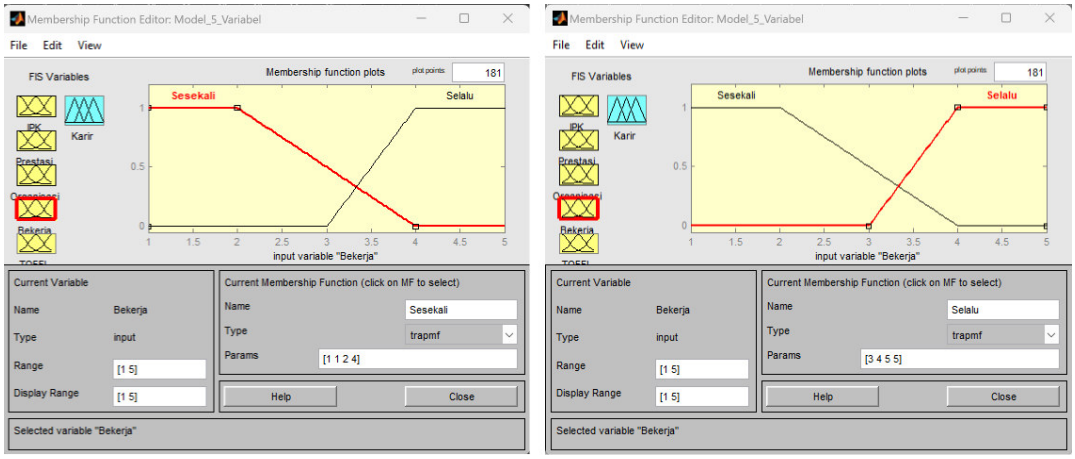

Figure 5. Display of membership function representation of work intensity variable

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5) TOEFL Score Variable

In the TOEFL score variable, the membership degree function of the LOW and HIGH fuzzy sets is represented with a trapezium curve while the MEDIUM uses a triangle curve. The representation for the TOEFL score variable can be seen in Figure 6 below

Figure 6. Display of membership function representation of TOEFL score variable

6) Career Variables

The membership degree function of the fuzzy sets WORK and ADVANCE in the career variable is represented with a triangular curve. The representation for career variables can be seen in Figure 7 below.

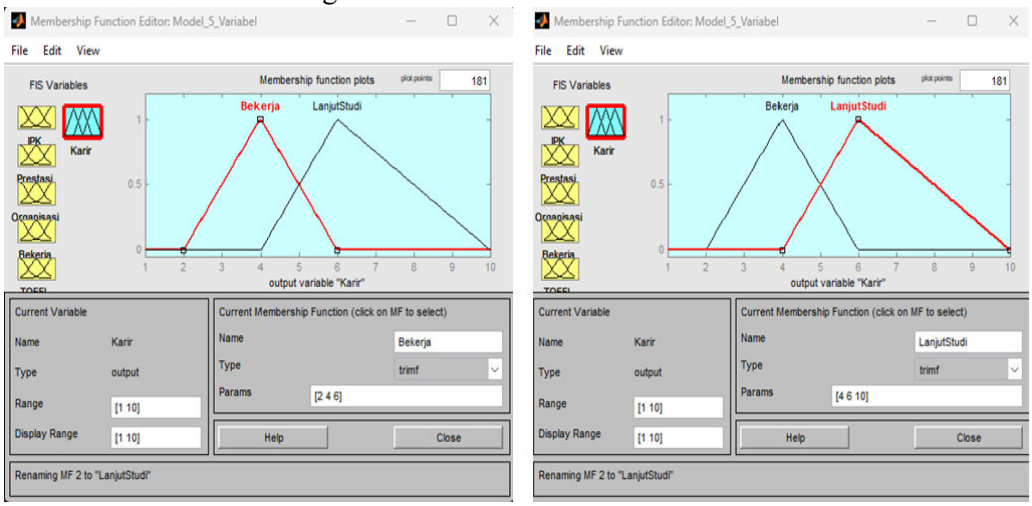

Figure 7. Representation view of career variable membership function

Fuzzy Rules

To get accurate system output results, the formation of rules must be examined properly. In determining the rules, besides being based on knowledge related to the system, the results of data analysis and testing by taking into account the possibilities that occur with variable combinations are needed. Researchers set 48 rules based on the number of fuzzy sets in each input variable. Of the 48 rules formed, based on several tests, researchers only set four rules that cause further study output, namely rule 39, rule 42, rule 45 and rule 48. Figure 8 is a display of 48 rules that have been inputted to the system in MATLAB.

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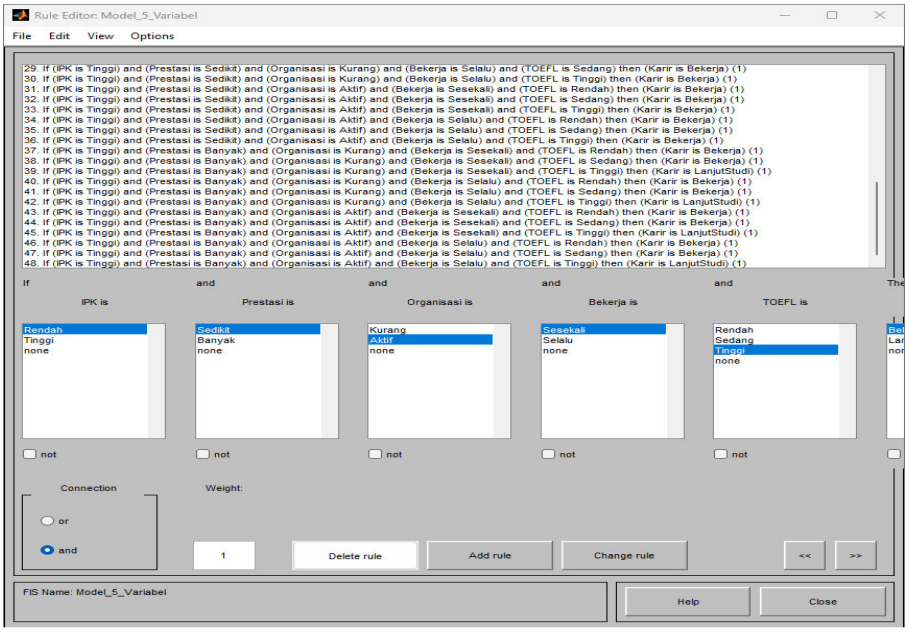

Figure 8. Rules window display

System Testing

To facilitate system testing, researchers conducted testing using MATLAB. After the data entry in MATLAB was completed, the researchers tested the system to forecast the career chosen by the Medan State University undergraduate program alumni based on the alumni profile obtained from the questionnaire. The results of the forecasting system will be compared with the actual data, namely the alumni career according to the questionnaire answers. The difference between the forecast data and the actual data is the basis for determining the accuracy of the forecasting system.

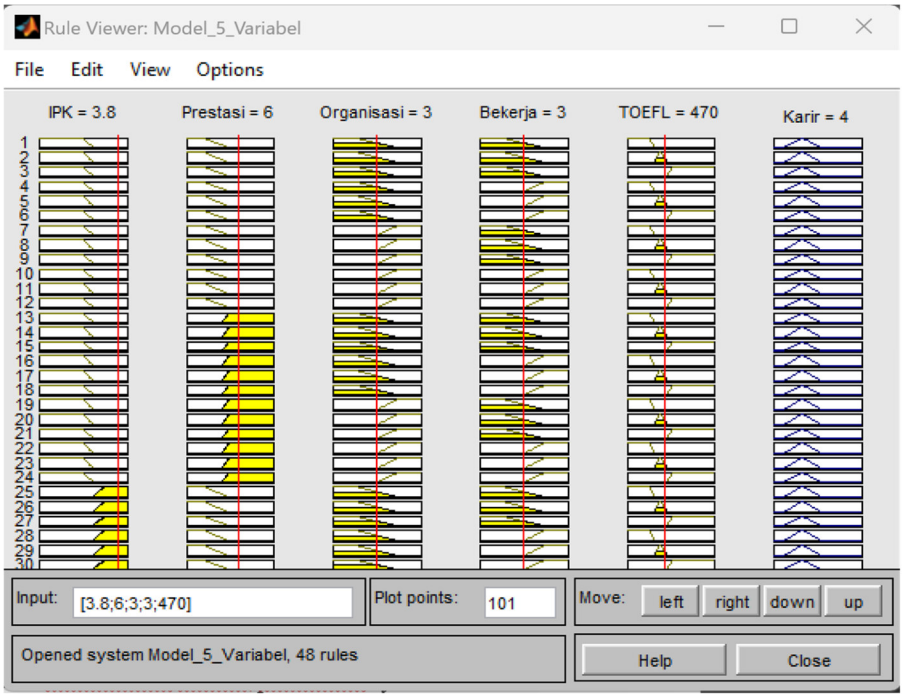

Figure 9. System testing display with MATLAB

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Figure 9 shows testing the system with MATLAB to predict the career chosen by alumni based on their profile. An alumnus who has a GPA of 3.8, many achievements 6, quite active in organizations (3), several times working (3) and a TOEFL score of 470 is predicted to choose a working career (4). Alumni careers are written in codes 1-10, namely 1) not working, 2) entrepreneurship, 3) working and entrepreneurship, 4) working, 5) working and continuing studies, 6) continuing studies at parents' expense, 7) continuing studies with scholarships, 8) continuing studies at independent expense, 9) continuing studies and entrepreneurship, 10) working, continuing studies and entrepreneurship.

Table 3. Test results of career prediction system using MATLAB

No.	GPA	Many Awards	Organizational activity	work intensity	TOEFL Score	Career Code (actual data)	Career Code (predicted data)	Error
1	3,8	6	3	3	470	4	4	0,0
2	3,66	1	2	1	480	4	4	0,0
3	3,36	1	3	2	450	3	4	33,3
4	3,3	0	3	4	400	6	4	33,3
5	3,36	1	3	1	500	4	4	0,0
6	3,46	3	4	4	440	4	4	0,0
7	3,57	10	4	5	490	4	6,78	69,5
8	3,3	1	3	2	440	4	4	0,0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
54	3,64	1	1	1	430	4	4	0,0
55	3,56	1	4	3	450	4	4	0,0
56	3,66	5	5	3	487	7	6,88	1,7
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
81	3,52	6	1	4	483	7	6,46	7,7
82	3,25	2	5	3	380	4	4	0,0
83	3,63	5	5	4	510	6	6,67	11,2
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
94	3,14	5	4	2	505	3	4	33,3
95	3,24	0	3	1	470	6	4	33,3
96	3,68	1	4	1	390	8	4	50,0
97	3,54	1	4	2	337	4	4	0,0
98	3,26	1	3	5	450	5	4	20,0
99	3,45	0	4	3	450	4	4	0,0
100	3,46	0	2	3	451	4	4	0,0
						MAPE		14,6

Table 3 displays the results of career predictions for 100 respondents using MATLAB. Based on the rules that have been set and the actual data available, the majority of the system shows the career predictions chosen by alumni are working. The career code 6.78 shows that the career chosen by alumni is to continue their studies at the expense of parents or scholarships, but closer to the cost of scholarships. The error value obtained from the difference between the predicted career code and the actual career code shows a varied value with the smallest value of 0, the largest is 69.5 and the average error value is 14.6. Based on the average error value obtained, the MAPE value is 14.6. This value indicates that the prediction accuracy is categorized as Good.

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Conclusion

To get accurate prediction output results, the model designed must be correct. The determination of the fuzzy set and the selection of the representation curve of the membership degree function of each variable must be precise. This selection will affect the determination of the rules made. Based on the model that has been designed, the accuracy of predicting the career of Medan State University undergraduate alumni shows a good predicate with a MAPE value of 14.6%. The prediction accuracy with this model is difficult to achieve the Very Good predicate because based on the fact that there are alumni who have low TOEFL scores continuing their studies.

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The Principal Component Analysis of Regional Wealth Factors of Indonesia

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Abstract. *The Regional Revenue and Expenditure Budget (APBD) is a one-year local government financial plan stipulated by regional regulations. This article examines the wealth of an area in terms of how big the budget of the region's income and expenditure is. The regional budget of 34 provinces in Indonesia is monitored directly by the Ministry of Finance. There are 32 variables monitored as part of the regional budget consisting of regional revenue, regional expenditure, surplus/deficit and regional financing. Using Principal Component Analysis (PCA), we look for variables that best represent the 33 variables to see which variables most determine the amount of regional budget for the 2019-2022 data year. The correlation between variables states that there is a strong correlation between 3 variables of regional expenditure each year, namely capital expenditure, other expenditures and subsidy expenditures that affect the regional budget. PCA results from APBD data for 2019-2022 show that regional income variables, regional levies, capital expenditures have always been variables forming the main components of the APBD.*

Keywords: Regional Wealth, PCA, APBD, Correlation, high dimension data.

Introduction

Regional wealth or commonly known as regional assets or regional property is regional wealth which essentially consists of movable and immovable assets. Movable assets, such as official vehicles, documents and so on. While immovable or fixed assets, such as land, buildings, and so on. Regional wealth is one of the components that play a role in supporting development in the region. In order for the regional wealth to be utilized optimally, it is necessary to have a clear regulatory mechanism for the utilization of the regional wealth which is the authority and responsibility of the regional government. Regional wealth is divided into owned regional wealth and separated regional wealth. Regional wealth owned is called Regional Property (BMD),

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which is all goods purchased or obtained at the expense of the Regional Budget or derived from other legitimate acquisitions (article 1 of Law No. 1 of 2004 concerning State Treasury). Meanwhile, regional wealth whose management is separated from the regional budget is called regional wealth that is separated. The existence of segregated regional wealth is partly due to local government investment in business entities, both state/regional owned companies (BUMN/BUMD) and private-owned companies. Regional investment in the form of separated regional wealth is expected to be a source of APBD revenue [1]

Indonesia is a country that has a lot of natural wealth. Even some of Indonesia's natural wealth is not owned by other countries, such as gold, petroleum, natural gas, coal to marine products scattered in various regions of Indonesia. Not all regions have great natural wealth. However, each region has assets, namely all regional wealth owned or controlled by local governments, purchased or obtained at the expense of the regional budget or derived from other legitimate acquisitions.

According to Mardiasmo in [1] regional wealth can be classified into two types, namely: (1) Wealth that has existed since the existence of the area. This type of wealth includes all natural and geographical wealth of its territory. Examples are land, forests, mines, mountains, lakes, beaches and seas, (2) The wealth that will be owned both comes from local government activities funded by the APBD and other regional economic activities. Examples are roads, bridges, vehicles, and other capital goods.

The following is the posture of the Indonesian Regional Budget with variables that affect regional income:

Table 1. Posture of APBD of Indonesia in variables.

Variable	Name of variable	Variable	Name of variable
x_1	Regional Revenue	x_{17}	The interest of the Spending
x_2	Regional Original Income (PAD)	x_{18}	Subsidies Spending
x_3	Local Tax	x_{19}	Grant Spending
x_4	Regional Levies	x_{20}	Social Assistance Spending
x_5	Results of Segregated Regional Wealth Management	x_{21}	Unexpected Spending
x_6	Other Valid PADs	x_{22}	Revenue Share Shopping
x_7	Central Government Transfer Revenue	x_{23}	Financial Assistance Spending
x_8	Other Revenue	x_{24}	Surplus/ (Deficit)
x_9	Inter-Regional Transfer Revenue	x_{25}	District Financing
x_{10}	Grant Income	x_{26}	District Financing Acceptance
x_{11}	Other Income in Accordance with the Provisions of Legislative Regulations	x_{27}	Remaining Over Calculation of Previous Year's Budget
x_{12}	Regional Spending	x_{28}	Regional Loan Receipt
x_{13}	Employee Spending	x_{29}	Regional Loan Readmission
x_{14}	Spending for Goods and Services	x_{30}	District Financing Withdrawal
x_{15}	Capital Expenditures	x_{31}	Regional Capital Participation
x_{16}	Other Spending	x_{32}	Mature Payment of Debt Principal Installments

Table 1 shows many variables that determine the value of a region's regional budget. For this reason, we want to see what factors greatly affect the APBD of all regions in Indonesia based on provinces in Indonesia.

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Methodology

To determine which variable affected regional wealth factors the most, in this study we take it from the components of the APBD posture, uses Principal Component Analysis (PCA) analysis. Data taken from the APBD Data Portal of the Directorate General of Financial Balance of Indonesia is as many as 32 variables. Researchers used APBD data from all Indonesian provinces as many as 34 provinces.

Principal Component Analysis

Principal component analysis (PCA) is an analytical technique used in the fields of statistics and data science. By utilizing this analysis technique, we can summarize the information contained in large data tables into several smaller sets of summary indexes. So, the stage of visualization and data analysis becomes easier to do. Principal component analysis (PCA) is a multivariate statistical analysis technique. Typically, PCA is used in the field of pattern recognition and signal processing [2] [3]. But other than that, [4] used this method to study the relationship between the rate of spread of COVID-19 in high-risk countries. [5] combined other methods with PCA to measure brain activity at different age levels. PCA is basically the basis of multivariate data analysis that applies projection methods. This analysis technique is usually used to summarize multivariate data tables on a large scale so that they can be used as a collection of smaller variables or summary indexes. From there, then variables are analyzed to find out certain trends, variable clusters, to outliers.

Steps to do Principal Component Analysis as (1) Standardize the range of continuous initial variables, (2) Compute the covariance matrix to identify correlations, (3) Compute the eigenvectors and eigenvalues of the covariance matrix to identify the principal components, (4) Create a feature vector to decide which principal components to keep, (5) Recast the data along the principal component axes.

Principal component analysis is a dimension method often used to reduce dimensionality of a large data set, by converting a large set of variables into smaller variables that still contain most of the information in a large set. Reducing the number of variables in a data set is usually comes at the expense of accuracy. The trick in dimensionality reduction is to swap out a bit of accuracy for simplicity's sake. Because smaller data sets are easier to explore and visualize and make data point analysis easier and faster for machine learning algorithms without extraneous variables to process.

PCA is a statistical interpretation of Singular Value Decomposition (SVD). It's captured the maximum amounts of the variance in the data.

We have data which present in matrix as below

$$A = [x_{11}\, x_{12}\, \dots\, x_{1n}\, x_{21}\, x_{22}\, \dots\, \dots\, \vdots\vdots\vdots\, x_{m1}\, x_{m2}\, \dots\, x_{mn}]$$

Which the mean of the row is

$$\underline{x}_n = \frac{1}{m}\sum_{i=1}^{m} x_{in}$$

Build an average matrix by multiplying a vector of ones with vector of $\underline{x}_n$ and get the new matrix:

$$\underline{X} = [1\,1\,\vdots\,1][\underline{x}_1\, \underline{x}_2\, \dots\, \underline{x}_n] = [\underline{x}_1\, \underline{x}_2\, \dots\, \underline{x}_n\ \underline{x}_1\, \underline{x}_2\, \dots\, \underline{x}_n\ \ddots\ \underline{x}_1\, \underline{x}_2\, \dots\, \underline{x}_n]$$

Get a new matrix $B = A - \underline{X}$. Since B is decomposes by SVD, then $B = U\Sigma V^t, U$ is an $m \times n$ orthogonal matrix V^t is an $n \times n$ orthogonal matrix and Σ is an $r \times r$ diagonal matrix with $r \leq \{m, n\}$. From the matrix of row of B, find the covariance matrix, $C = B^T B$.

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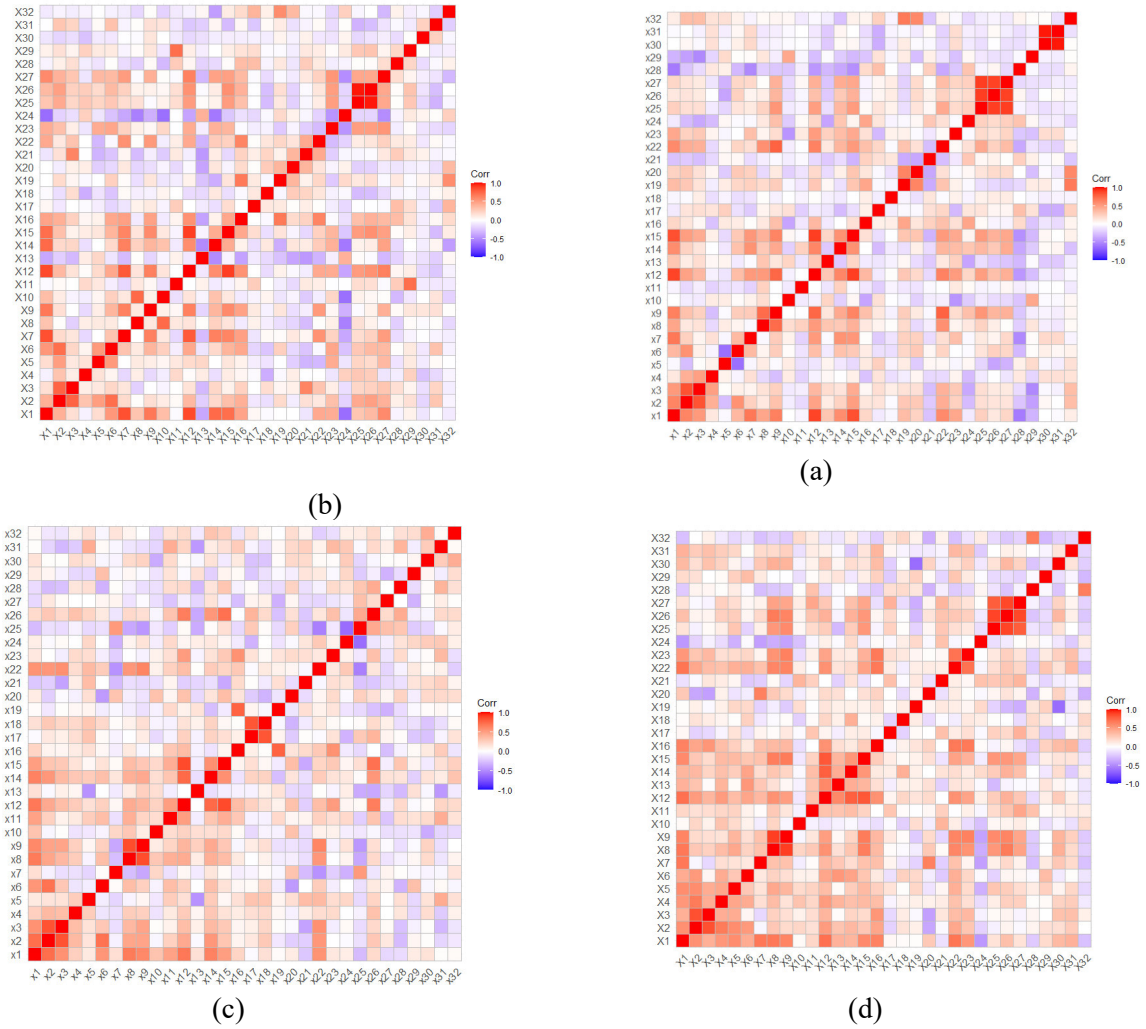
Then, compute the Eigen values of C and get the Eigen vector of C.
Furthermore, $C.V = V.D$
Where V is Eigen vector dan D is Eigen value.
So, $T = BV$, where T is the principal components, then V will call the loadings.
Since $B = U\Sigma V^t$ then $T = U\Sigma V^t V = U\Sigma$
The Eigen value $\lambda = \sigma^2$, where σ is a singular value of B and σ^2 is also the variance of the principal components in the data.

Result and discuss

The aims of this study are to find the most effected variables from 32 variables in APBD as the regional wealth of each province in Indonesia. Principal Component Analysis consist of five step to analyze. However, the goals of PCA are: (1) extract the most important information from the data table; (2) compress the size of the data set by keeping only this important information; (3) simplify the description of the data set; and (4) analyze the structure of the observations and the variables.[6]

From data on the posture of the APBD of Indonesia we get data APBD of 34 provinces in Indonesia. Data collected from 2019 to 2022. R mathematics application helped us to compute all the value then we got the correlation as shown in the following figure.



(a) (b) (c) (d)

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Figure.1. Correlation between variables in years 2019, 2020, 2021 and 2022 present in (a), (b), (c), and (d) respectively.

From the picture above, it can be seen that multicollinear occurs in $x_2, x_3, x_8, x_9, x_{17}, x_{18}, x_{25}, x_{26}, x_{27}, x_{30}, x_{31}$. Fortunately, PCA used to address data with multicollinearity [7, 8, 9, 10]. From the correlation plot explained that variable x_2 and x_3, which are regional original income (PAD) and regional taxes, are always have a strong correlation. This is in line with research results [11] which state that the results of this research show that regional tax variables, regional levies, results of separated regional wealth management and other legitimate regional income simultaneously influence regional spending.

We also get that variable x_{25} and x_{26}, which are district financing and district financing acceptance, are often in a strong correlation one to each other. It's mean that even district financing acceptance build from many variables that it's taken from.

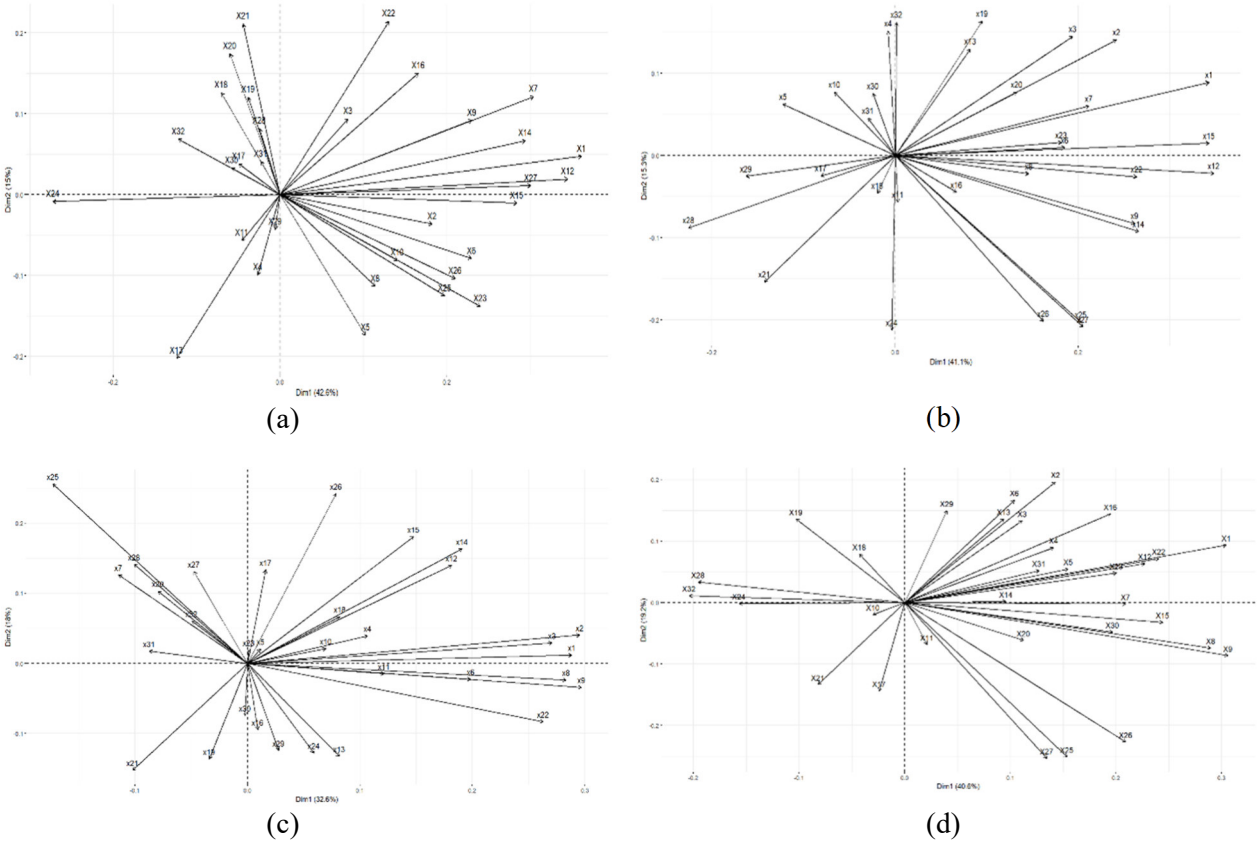

Figure.2. PCA for years 2019, 2020, 2021 and 2021 pictures in (a), (b), (c), and (d) respectively.

From the picture above, it can be seen that in 2019 the first and second component formers are variable $x_1, x_3, x_7, x_9, x_{12}, x_{14}, x_{16}, x_{22}, x_{27}$.
In 2020 there are variables $x_1, x_2, x_3, x_6, x_7, x_{13}, x_{15}, x_{19}, x_{20}, x_{23}$.
In 2021 there are variables $x_1, x_2, x_3, x_4, x_5, x_{12}, x_{14}, x_{15}, x_{17}, x_{23}, x_{26}$.
And in 2022 there are variables $x_1, x_2, x_3, x_4, x_5, x_6, x_{12}, x_{13}, x_{16}, x_{22}, x_{23}, x_{29}, x_{31}$.

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Conclusion

The conclusion of this research is that the first and second components can't explain accurately all the data of regional wealth. Yet, known by the variables that composed the first and second component, there are always exist $x_1, x_2, x_3, x_{12}, x_{23}$ for Regional Revenue, Regional Original Income (PAD), Local Tax, Regional Spending and Financial Assistance Spending. These factors are a concern in determining how much wealth a region in Indonesia has.

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Solutions of nonlinear differential equations system on infectious disease using perturbation homotopy method

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Abstract. *This article is part of a research study that discusses the dynamics of COVID-19 infectious disease using the SEIR model with the Homotopy Perturbation Method (HPM). The mathematical model formed is a non-linear system of differential equations with four variables, namely the susceptible variable (S), the exposed variable (E), the infected variable (I), and the recovered variable (R). The data used is secondary data from Ruth's (2022) research on COVID-19 cases in North Sumatra Province. Analytically obtaining a solution for the non-linear system of differential equations that describes the spread of COVID-19 is challenging; therefore, the solution is obtained using a numerical approach, namely HPM. The results of the simulation with HPM are compared to the results of Runge-Kutta Order 4, and the errors are calculated. The simulation results show that the solution to the non-linear system of differential equations in the spread of infectious COVID-19 can be solved using HPM, and the results are accurate with very small errors.*

Keywords: Covid-19, mathematical model, homotopy perturbation method, numerical simulations

Introduction

Mathematical modeling is a mathematical representation of a real-world phenomenon that involves concepts, equations, and mathematical structures to describe, analyze, and understand the behavior, relationships, or characteristics of the system or situation under study [1]. The goal of mathematical modeling is to simplify the complexity of real-world phenomena so that we can

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analyze, forecast, or make better decisions [2]. Mathematical modeling often involves simplifying complexity by identifying important variables, developing equations or systems of equations, and using mathematical analysis techniques to gain insights or predictions [3]. This allows us to test various scenarios and make more informative decisions in various contexts.

Mathematical modeling in the spread of diseases is the use of concepts, mathematical equations, and other mathematical tools to describe and analyze how an infectious disease spreads among a population. The primary purpose of this modeling is to aid in understanding, predicting, and controlling the spread of the disease [4]. The disease spread system, the mathematical model takes the form of a nonlinear differential equation with several interrelated variables and parameters. The solution to a system of non-linear equations is analytically quite complicated to solve, so an approximate solution is required which is known as a numerical approximate solution. One of these methods is the Homotopy perturbation method. The Homotopic Perturbation method is a semi-analytic technique for solving non-linear differential equations. Some researchers now use numerical techniques such as the Adomian Decomposition Method introduced by [5], the Variational Iteration Method introduced by [6], and the Homotopy Perturbation Method introduced by [7] to obtain their approximate solutions. Authors such as [8] used homotopy perturbation methods to analyze Equine Infectious Anemia Virus (EIAV) models. [9] used a homotopy perturbation method to obtain approximate solutions to fractional order integral-differential equations. Their results converge more quickly to the correct solution compared to other numerical methods. [10] discusses the future conditions of COVID-19 SIR model based on real data.

The spread of Covid-19 can be modeled using a mathematical model [11]. Mathematical model is a tool that can play a role in studying the spread of disease, which is commonly referred to as a mathematical model of epidemiology [12]. The classic model of the spread of disease was formulated by Kermack in 1927, known as SIR (Susceptible, Infected and Recovered) model. In SIR model, the total population is divided into 3 subpopulations, namely Susceptible which states the number of healthy individuals but susceptible to infection, Infected which states the number of individuals who are infected and can transmit the disease, and Recovered which states the number of recovered individuals. Some diseases have a latent period (incubation period), which is the time between healthy individuals who become infected and can transmit the disease. This period resulted in the emergence of a new subpopulation, namely Exposed. With these additions, the SIR model was developed and became the SEIR model. Thus, in this study, the spread of Covid-19 was studied using the SEIR model which refers to [13]. The mathematical model used in analyzing the spread of disease is in the form of a system of nonlinear differential equations which will later be solved to obtain an analytical solution. However, there is one thing to note that not all solutions to nonlinear differential equations can be obtained by analytical solutions. Therefore, a numerical approach can be used to produce a solution that is close to the actual solution. Homotopy Perturbation Method is a semi-analytic method used to solve various linear and nonlinear differential equations.

Homotopy Perturbation Method (HPM) was first proposed by a Chinese mathematician named Ji-Huan He [14]. The method, enables analytical solutions of many problems in various fields as it uses the idea of homotopy from topology to generate a suitable convergent series solution for nonlinear differential equations. Benefits of HPM which distinguished it from other analytical methods include, HPM is a series expansion method that indirectly dependent on small or large physical parameters. Therefore, it can be used to solve both varieties problems. It gives convergent series solutions and the perturbation equation is easy to construct. He used HPM to

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solve schrodinger equation [15], initial value problems. Mathematical modelling enables us to predict possible disease control strategies by considering transmission dynamics of the disease, determining the threshold parameters such as the basic reproduction number and carrying out endemic equilibrium, stability analysis and sensitivity analysis.

Mathematic model

Basic consept of homotopy perturbation method

Consider the following functions:

$$A(u) - f(r) = 0 \text{ where } r \in \Omega \quad (1)$$

Subject to boundary conditions:

$$B\left(u, \frac{\partial u}{\partial n}\right) = 0 \text{ with } r \in D \quad (2)$$

Where $A, B, f(r)\ and\ D$ stand for a general differential operator, a boundary operator, a known analytic function and a boundary of the domain (Ω) respectively. Where the operator A is divided into two parts; the Linear part (L) and the nonlinear part (N), now we can rewrite equation (1) as:

$$L(u) + N(u) - f(r) = 0 \quad (3)$$

By homotopy techniques, we construct a Homotopy defined by:

$V(r,p): \Omega \times [0,1] \rightarrow R$ such that $V(x,0) = v(x)$ dan $V(x,1) = g(x)$ which satisfies:

$$H(v,p) = (1-p)[L(v) - L(u_0)] + p[A(v) - f(r)] = 0 \quad (4)$$

By expanding $H(v,p)$ we obtain:

$$H(v,p) = L(v) - L(u_0) + pL(u_0) + p[N(v) - f(r)] = 0 \quad (5)$$

Where $p \in [0,1]$ is an embedding parameter, while u_0 is an initial approximation of equation (1) which satisfies the boundary condition. Obviously (4) and (5)

$p = 0$ and $p = 1$, equation becomes:

$$H(v,0) = L(v) - L(u_0) = 0 \quad (6)$$

$$H(v,1) = A(v) - f(r) = 0 \quad (7)$$

The changing process of p from zero to one is just a change of $V(r,p)$ from $uo\ \ u(r)$. In topology the process is called $Deformation$, and $L(v) - L(u_0)\ and\ A(v) - f(r)$ are known as homotopy.

According to Homotopy perturbation method, we first use the embedding parameter "P" as small parameter and assume that the solution of the equation (4and 5) can be written as a power series in "p" as

$$v = v_0 + pv_1 + p^2 v_2 + \cdots \quad (8)$$

Setting $p = 1$ result in the approximate solution of equation (1) that is [15]:

$$u = V = v_0 + v_1 + v_2 + \cdots \quad (9)$$

Infectious Disease SEIR Model

In order to formulate our problem, we assume that $S(t)$ represents number of susceptible human at time t; $E(t)$ represents number of exposed human in the population at time t,$I(t)$ represents number of infected human in the population which is infected from the Covid-19 disease at time t; $R(t)$ represents number of human in the population which is recovered at time t. The total population size is $N(t) = S(t) + E(t) + I(t) + R(t)$. We get the following system of four differential equations and through the process of simplifying the system by assuming $s = \frac{S}{N}$; $e =$

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$\frac{E}{N}; i = \frac{I}{N}$ and $r = \frac{R}{N}$ we obtain a system of equations as follows: is given by:

$$\begin{aligned} \frac{ds}{dt} &= \mu - (\alpha i + \mu + v)s \\ \frac{de}{dt} &= \alpha i s - (\beta + \mu)e \\ \frac{di}{dt} &= \beta e - (\gamma + \delta + \mu)i \\ \frac{dr}{dt} &= \delta i + vs - \mu r \end{aligned} \quad (10)$$

With the initial conditions $s(0) \geq 0, e(0) \geq 0, i(0) \geq 0, r(0) \geq 0$

μ represents the growth rate of human population. The Covid-19 disease transmission rate represented by α. The direct transmission between exposed human and infected human is represented by β. The natural death rate for the human is μ. The death rate due to Covid-19 for the human is represented by δ. The rate of recovery from the infection is shown by γ. The individuals are susceptible again at v. From Eq. (10), the initial condition for the equation is s(0) = 0, e(0(=0, i(0)=0 and r(0)=0. Based on real data recorded in the city of Medan, initial values are obtained for the variables and parameters used in the COVID-19 spread model are presented in the following table:

Tabel 1. Description of Variables, Parameters, Condition and Value

Variable/ Parameters	Description	Condition	Value
s	A population of individuals susceptible to infection with a virus over time.	$s \geq 0$	0,936347[1]
e	Populations of individuals infected with the virus without symptoms over time	$e \geq 0$	0,034512[1]
i	A population of individuals infected with a virus with symptoms over time	$i \geq 0$	0,000122[1]
r	Population of individuals who recover over time	$r \geq 0$	0,029019[1]
μ	Natural birth/death rate	$\mu \geq 0$	0,00046
α	Rate of susceptible individuals infected	$\alpha \geq 0$	0,4
β	Rate of Exposed individuals becomes Infected	$\beta \geq 0$	0,081
γ	Death rate due to Covid-19 infection	$\gamma \geq 0$	0,0443
δ	Rocovered rate	$\delta \geq 0$	0,099
v	The individuals are susceptible rate	$v \geq 0$	0,00012

[1)] The value is obtained from the results of data processing with real data from the city of Medan

Result and simulation

Result

Now, we apply the homotopy perturbation techniques to our model (8). We assume for simplifications $s^*(t) = s, e^*(t) = e, i^*(t) = i$ and $r^*(t) = r$.

The initial data we consider is given by:

$$\begin{aligned} &(1-p)\left(\frac{ds}{dt} - \frac{ds_0}{dt}\right) + p\left(\frac{ds}{dt} - \mu + vr + (\mu + (\alpha i)s + vr\right) = 0 \\ &(1-p)\left(\frac{de}{dt} - \frac{de_0}{dt}\right) + p\left(\frac{de}{dt} - \alpha i s + (\beta + \mu)e)\right) = 0 \\ &(1-p)\left(\frac{di}{dt} - \frac{di_0}{dt}\right) + p\left(\frac{di}{dt} - \beta e + (\gamma + \delta + \mu)i\right) = 0 \\ &(1-p)\left(\frac{dr}{dt} - \frac{dr_0}{dt}\right) + p\left(\frac{dr}{dt} - \delta i - vs + \mu r\right) = 0 \end{aligned} \quad (11)$$

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In using the homotopy perturbation method, the solution to the equation is assumed to be in the form of a power series. The form of the power series is defined in the equation as below:

$$\begin{aligned} s(t) &= s_0(t) + ps_1(t) + p^2 s_2(t) + p^3 s_3(t) + \cdots \\ e(t) &= e_0(t) + pe_1(t) + p^2 e_2(t) + p^3 e_3(t) + \cdots \\ i(t) &= i_0(t) + pi_1(t) + p^2 i_2(t) + p^3 i_3(t) + \cdots \\ r(t) &= r_0(t) + pr_1(t) + p^2 r_2(t) + p^3 r_3(t) + \cdots \end{aligned} \quad (12)$$

Where p ∈ [0, 1] is a parameter and s_0, e_0, i_0 and r_0 are values initial approach to solving the system. If equation (12) and the calculation results The derivative is substituted into equation (11), then we obtain:

$$(1-p)\left[\frac{ds_0}{dt} + p\frac{ds_1}{dt} + p^2\frac{ds_2}{dt} + p^3\frac{ds_3}{dt} + \cdots - \frac{ds_0}{dt}\right] + p\left(\frac{ds_0}{dt} + p\frac{ds_1}{dt} + p^2\frac{ds_2}{dt} + p^3\frac{ds_3}{dt} + \ \ldots - \mu + \mu(s_0(t) + ps_1(t) + p^2 s_2(t) + p^3 s_3(t) + \cdots + \alpha(i_0(t) + pi_1(t) + p^2 i_2(t) + p^3 i_3(t)(s_0(t) + ps_1(t) + p^2 s_2(t) + p^3 s_3(t) + \cdots + v(r_0(t) + pr_1(t) + p^2 r_2(t) + p^3 r_3(t) + \cdots = 0\right) \quad (13)$$

By collecting the same order we obtain:

$$\left(\frac{ds_0}{dt} - \frac{ds_0}{dt}\right)p^0 + \left(\frac{ds_1}{dt} + \frac{ds_0}{dt} - \mu + \mu s_0\alpha i_0 + v\right)p^1 + \left(\frac{ds_2}{dt} + \ \mu s_0\alpha i_1 + \alpha s_2 i_0\right)p^2 + (\frac{ds_3}{dt} + \alpha s_0 i_2 + \alpha s_1 i_1 + \alpha s_2 i_0 + \mu s_2 + \ vr_2)p^3 + \cdots = 0 \quad (14)$$

From equation 14 for the susceptible variable the coefficient is obtained

$$\begin{aligned} p^1 &: \ \frac{ds_1}{dt} + \frac{ds_0}{dt} - \mu + \mu s_0\alpha i_0 + vr_0 = 0 \\ p^2 &: \ \frac{ds_2}{dt} + \ \mu s_0\alpha i_1 + \alpha s_2 i_0 \\ p^3 &: \ \frac{ds_3}{dt} + \alpha s_0 i_2 + \ \ \alpha s_1 i_1 + \alpha s_2 i_0 + \mu s_2 + \ vr_2 = 0 \end{aligned} \quad (15)$$

In the same way, the exposed variable (e), infected variable (i) and recovered variable (r) can be found for each order. After integrating, the next step is to enter the initial values. The solution obtained from S, E, I, R using the Homotopy Perturbation Method up to the third order is:

$$\begin{aligned} s(t) &= \textstyle\sum_{j=0}^{3} \quad s_j = 0{,}936347 + 0{,}0000225t - 0{,}0001593t^2 + 0{,}0000135t^3 \\ e(t) &= \textstyle\sum_{j=0}^{3} \quad e_j = 0{,}034512 - 0{,}003801t + 0{,}0003692t^2 - 0{,}00002709t^3 \\ i(t) &= \textstyle\sum_{j=0}^{3} \quad i_j = 0{,}000122 + 0{,}003778t - 0{,}0004807t^2 + 0{,}00003657t^3 \\ r(t) &= \textstyle\sum_{j=0}^{3} \quad r_j = 0{,}029019 - 0{,}00000476t + 0{,}0001871t^2 - 0{,}00001591t^3 \end{aligned} \quad (16)$$

The results of solving equation (16) will be compared with the Runge Kutta method of order 4, then the error will be determined

Simulation

Numerical Result

In this section, we discuss the numerical solution of the proposed model. First, we solve the model numerically and then discuss these results. For numerical simulation we consider the parameter values presented in table 1. Simulation results using Maple for the susceptible variable between the Homotopy perturbation method (HPM) and the 4th order Runge Kutta method (RK4) are given in table 2 as follow:

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Table 2. Comparison of susceptable population and errors between the hpm and rk4

t	S_{HPM}	S_{RK4}	Error
0	0.936347	0.936347	0
0.1	0.93634767021839	0.936347670506966	$3x10^{-10}$
0.2	0.93634523646805	0.936345236626294	$1x10^{-10}$
0.3	0.93633977694220	0.936339776876553	0
0.4	0.93633136762617	0.936331368031481	$4x10^{-10}$
0.5	0.93632008467819	0.936320085157088	$5x10^{-10}$
0.6	0.93630600162676	0.936306001648025	0
0.7	0.93628919001566	0.936289189263231	$7x10^{-10}$
0.8	0.93626971851158	0.936269718160868	$3x10^{-10}$
0.9	0.93624765679587	0.936247656932556	$1x10^{-10}$
1.0	0.93622307346355	0.936223072636923	$9x10^{-10}$

Next, a distribution graph for the Exposed population will be presented in table 3 as follow:

Table 3. Comparison of eksposed population and errors between the hpm and rk4

t	e_{HPM}	e_{RK4}	Error
0	0.034512 0.034512	0.034512 0.034512	0
0.1	0.034135462989158	0.0341354736230914	$1.063x10^{-8}$
0.2	0.033766157097744	0.0337661707817236	$1.359x10^{-8}$
0.3	0.033403947810599	0.0334039342222249	$1.368x10^{-8}$
0.4	0.033048645367976	0.0330486101489416	$3.522x10^{-8}$
0.5	0.032700048416556	0.0327000481494557	$2.7x10^{-10}$
0.6	0.032358106893339	0.0323581011213526	$5.77x10^{-9}$
0.7	0.032022636119035	0.0320226252005100	$1.092x10^{-8}$
0.8	0.031693475262332	0.0316934796908797	$4.43x10^{-9}$
0.9	0.031370514531617	0.0313705269957330	$1,247x10^{-8}$
1.0	0.031053643804997	0.0310536325503435	$1.12x10^{-8}$

Table 3 shows that the exposed population value (e) obtained using the HPM method is not much different from the RK4 method, it could even be said to be very close, seen from the very small error, even for ten decimal places the error is zero. Next, the resulting values for the infected population will be presented in the following table

Table 4. Comparison of infected population and errors between the hpm and rk4

t	i_{HPM}	i_{RK4}	Error
0	0.000122	0.000122	0
0.1	0.0004951072902066	0.0004951072547911	$3,54x10^{-11}$
0.2	0.0008588171851131	0.0008588166138822	$5.71x10^{-10}$
0.3	0.0012133404069405	0.001213340241450	$1.66x10^{-10}$
0.4	0.0015588852904755	0.001558885575000	$2.85x10^{-10}$
0.5	0.0018956551039369	0.001895655430186	$5.00x10^{-10}$
0.6	0.0022238477498085	0.002223848103323	$3.26x10^{-10}$
0.7	0.0025436566909344	0.002543657471652	$3.53x10^{-10}$
0.8	0.0028552728648448	0.002855273091394	$2.26x10^{-10}$
0.9	0.0031588795155980	0.003158880293643	$7.78x10^{-10}$
1.0	0.0034546596849476	0.003454660278157	$5.93x10^{-10}$

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Table 4 shows a comparison of the completion results between MPH and RK4 for the infected population. The MPH method provides very good estimates with high accuracy approaching the RK4 calculation results. The results show that at the beginning of time, the infected population increased due to the addition of the exposed population entering the infected class, then decreased again. This is because some of the Infected population were declared cured of Covid-19 and entered the Recovered population.

For the recovered population (r) the simulation results using the homotopic perturbation method show high accuracy, the error given is very small and can even be ignored, this shows that the homotopic perturbation method can be used to find solutions of non-linear differential equations system. And when compared with the Runge Kutta Order 4 homotopic perturbation method the results are quite accurate.

Conclusion

The solution to the system of non-linear differential equations built from the SEIR mathematical model on the spread of the COVID-19 disease can be found using the homotopic perturbation method. Through the analysis process using the homotopy perturbation method, a series is obtained which is the numerical scheme of the homotopic perturbation method. Functional equations for Susceptible variables (s), exposed variables (e), infected variables (i) and recovered variables (r), are completed and simulated. The solution obtained was compared with the Runge Kutta Order 4 method, the comparison results for each variable showed that it was very accurate with very small errors, even negligible.

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Analysis of Mathematical Critical Thinking Abilities of Middle School Students Studying With a Brain-Based Learning Approach

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Abstract. *Critical thinking is one of the significant assets in living life in modern times so that you can adapt to facing problems. When a problem is designed to use critical thinking skills, students will get used to analyzing and identifying a problem, relating it to others, and then evaluating it before making a decision that is believed to be correct. So that students in real life will solve problems well are taken with consideration and care. This paper aims to analyze the mathematical critical thinking abilities of junior high school students who use the Brain Base Learning approach in learning. The data analysis technique used was descriptive analysis for 34 class VII students. The research results show that the highest aspect of critical thinking is interpretation ability, with an average score of 92.64, followed by analytical ability, with an average score of 71.32; evaluation ability is 62.5; and the aspect of critical thinking ability is inference, with an average score of 55.88. This research shows that brain ability-based learning can make it easier for students to interpret and analyze mathematical problems. Increasing the critical thinking aspects of mathematics, interpretation, evaluation, and inference is included in the medium category, while increasing critical mathematical abilities in the analytical aspect is included in the low category.*

Keyword: critical thinking, brain based learning, mathematics

Introduction

Critical thinking is one of the essential goals in Indonesian education because it helps students adapt to problems faced in real life. Critical thinking can determine the extent to which a problem can be precisely defined, so several criteria can be obtained that become a reference in

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solving the problem. Critical thinking skills are part of the mathematical thinking skills that every student must have in facing and solving various issues [1]. To realize this goal, the government has implemented it through Mathematics learning [2]. Learning mathematics at school can be a means for students to hone their thinking skills. However, until now, mathematics learning in schools has not provided many opportunities for students to develop critical thinking skills.

Critical thinking is solving problems systematically by describing problems, providing opinions, carrying out deductions and inductions, evaluating, and making decisions [3]. Critical thinking has quite a significant influence on reasoning. Critical thinking can be used to analyze and develop arguments as cohesive and logical reasoning patterns [4]. People who think critically will conduct a search, make conclusions based on facts, and then make a decision.

One of the characteristics of people who think critically is that they always explore and show the relationship between the problem being discussed and other relevant problems or experiences. Critical thinking skills are essential for students because this ability will help students in solving story problems or questions related to everyday life. Students who develop critical thinking skills will find it easier to solve the problems given [5]. However, the fact is that junior high school students' critical thinking abilities are still relatively low. This can be seen from the Program for International Student Assessment (PISA) survey results in 2015. Indonesia was ranked 63rd out of 72 participating countries with an average score of 386, lower than the international average score of 490. Facts in the field show that critical thinking skills students in Indonesia, especially junior high school students, still need to improve. Research conducted by [6] shows that the cause of students' low critical thinking skills is a lack of practice so that students find it challenging to solve the questions given by the teacher, and an appropriate learning approach is needed that can support students to develop critical thinking skills and become better at solving problems in a mathematical context.

Success in learning is mainly determined by the circumstances of the learning process experienced by students. The Brain-Based Learning model is one alternative learning model that can improve students' mathematical abilities, create fun, carefree learning conditions, and actively involve students. Brain Based Learning is a comprehensive and fundamental study of the brain's workings, which suggests the brain learns naturally. Brain-Based Learning is now a standard program in learning. Based on various research that has been conducted, students who are given Brain-Based Learning show better results than students who are given conventional learning [7], [8].

Brain-Based Learning is a learning model that coincides with how the brain is designed naturally to learn. The brain is the most essential part of the human being. The brain carries out various functions of the human body, such as thinking, speaking, and behaving. In learning, the brain plays a vital role because without thinking, humans cannot accept lessons [9], [10].

Why the Brain-Based Learning (BBL) learning approach can encourage students to think critically. First, the BBL approach encourages students to maximize the abilities of the left brain and right brain so that students feel relaxed, which will give rise to lots of critical thinking.

Second, the Brain-Based Learning learning approach is learning with real problems that reduce students' boredom about learning mathematics so that students will feel that learning mathematics can be applied in everyday life. The brain-based learning model can make it easier for students to optimize learning by utilizing all of the students' brain functions. The pattern of functional development of a person's brain is characterized by maturity [11], [12]. Brain-based

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learning can improve students' critical thinking abilities through various specific skills, such as quickly searching for opportunities and probabilities, debating and discussion skills, identifying errors, discrepancies, and incoherence [13], [14]. This analysis of students' critical thinking skills is expected to provide an overview of the extent to which students can use critical thinking skills to solve mathematical problems in real-world contexts through Brain-Based Learning.

Research method

This type of research is descriptive research, which aims to describe a situation without manipulating the research object. This research aims to analyze the mathematical critical thinking abilities of junior high school students who use the BBL approach in learning mathematics. This research was conducted at a private MTs in Medan, with the research subjects being class VII-1 students for the 2022/2023 academic year, totaling 34 students. The instruments used in this research were pretest and posttest questions on critical thinking skills. Each mathematical critical thinking pretest and posttest question consists of four questions representing aspects of critical thinking composed of 1) interpretation, 2) analysis, 3) evaluation, and 4) inference. The test is used to obtain student representation data in solving triangle and quadrilateral problems after being given Brain-Based Learning lessons.

To determine the increase in students' critical thinking skills, N-gain is used which is normalized as follows.

$$g = \frac{Spostest - Spretest}{Smaksimum - Spretest}$$

By criteria:

$g \geq 0,7$: high, $0,3 \leq g < 0,7$: middle, $g < 0,3$: low

Result and Discussion

The research results were described by analyzing data on students' critical thinking abilities before and after treatment in the form of implementing the Brain-Based Learning learning model. Analysis is used to see a picture of students' critical thinking abilities before and after treatment. Before being analyzed, pretest and posttest score data were converted to a scale of 100.

A summary of the results of descriptive analysis of pretest and posttest data on the critical thinking abilities of students who were taught Brain-Based Learning is presented in Table 1.

Table 1. Data description of students' critical thinking abilities

Statistic Descriptive	Pretest	Posttest
N	34	34
Mean	54,59	70,58
Median	50,00	71,87
Variance	156,98	162,23
Std. Deviation	12,52	12,73
Minimum	31,25	43,75
Maximum	75	87,50

Table 1 shows that the average posttest score for students' critical thinking abilities after learning with the Brain-Based Learning learning model is higher than the average pretest score for students' critical thinking abilities before being taught with the Brain-Based Learning learning model. Furthermore, the standard deviation of the pretest scores is almost the same as

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the standard deviation of the posttest.

The results of the analysis of students' critical mathematical thinking abilities based on aspects of critical thinking abilities can be seen in the following graph.

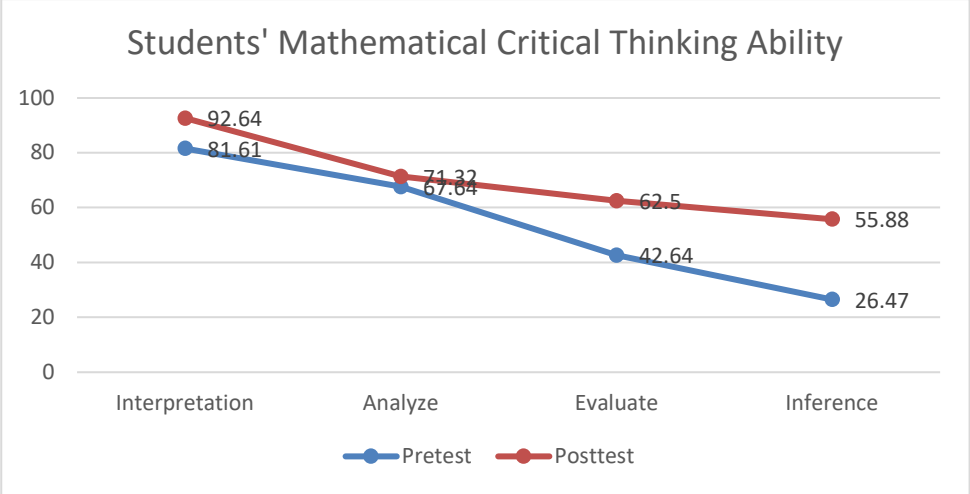
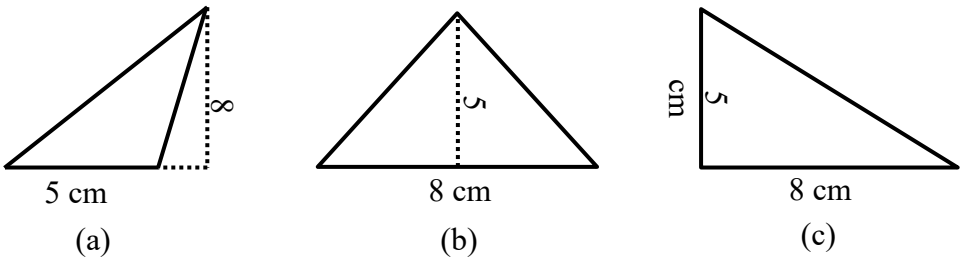


Figure 1. Graph of students' mathematical critical thinking ability

The graph shows increased students' mathematical reasoning abilities before being given Brain-Based Learning learning actions, which can be seen from the pretest and posttest results. Students' critical thinking abilities in interpreting, with an average pretest score of 81.61, increased after being taught Brain Based Learning with a posttest score of 92.64. The indicator of solving in critical thinking is understanding the problem indicated by writing what is known or what the question is asked correctly. According to Bloom's taxonomy, understanding is still in C2, so interpreting is naturally the highest of all other elements of critical thinking abilities. The following are questions about students' mathematical critical thinking abilities and students' answers to the interpreting aspects given during the pretest.

Question: Look at the following picture.



Of the triangles, which is wider? Give reasons.

One of the students' answers to this problem can be seen in the picture below.

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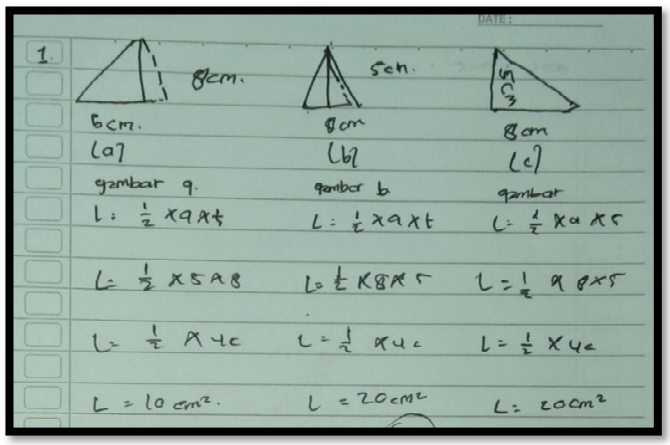

Figure 2. Students' answers to the mathematical critical thinking aspect of interpretation

Students' critical thinking skills in the analyze aspect with an average student pretest score of 67.64 during the pretest and 71.32 during the posttest. In evaluate, the average student pretest score was 42.64, and the posttest score was 62.5. Students' critical thinking abilities in the inference aspect, with an average student pretest score of 26.47, experienced an increase after being taught Brain Based Learning with a posttest score of 55.88.

This research shows that brain-based learning can make it easier for students to interpret and analyze this because in the elaboration syntax in brain-based learning, teachers give students the freedom and flexibility to search, filter, analyze, and deepen learning material through discussion with their groups so that students will be more active in participating and conveying their mathematical ideas and opinions.

To find out the extent which students' critical thinking skills have increased, gain normalization is used using pretest and posttest scores. The results of increasing critical thinking skills for the four indicators can be described in the following table:

Table 2. N-Gain of Students' mathematical critical thinking ability

Students' Critical Thinking Ability	Average Student Score		N-Gain	Category
	Pretest	Posttest		
Interpretation	81.61	92.64	0.59	Middle
Analyze	67.64	71.32	0.11	Low
Evaluate	42.64	62.5	0.34	Middle
Inference	26.47	55.8	0.39	Middle

The table above shows that the increase in students' critical thinking skills in interpreting, evaluating, and inferring is included in the medium category. Only the analyzing aspect is a low criterion. The analytical aspect ability score is the highest score after interpreting with an increase in the low category with an N-Gain of 0.11. The indicator of mathematical critical thinking, the analytical aspect, is identifying relationships between statements, questions, and concepts given in the problem, which is demonstrated by creating appropriate mathematical models and providing proper explanations. The questions used in the analyzing aspect can be seen as follows.

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Question: Look at the following picture of the Malay Deli traditional house.

Figure 3. Image of traditional house used in the problem

The picture above shows a shape in the shape of an isosceles triangle. If the circumference is 23 cm, the height is 8 cm, and the base side is 5 meters less than the foot side. Create a mathematical model to calculate the area of the flat triangular shape. Student answers:

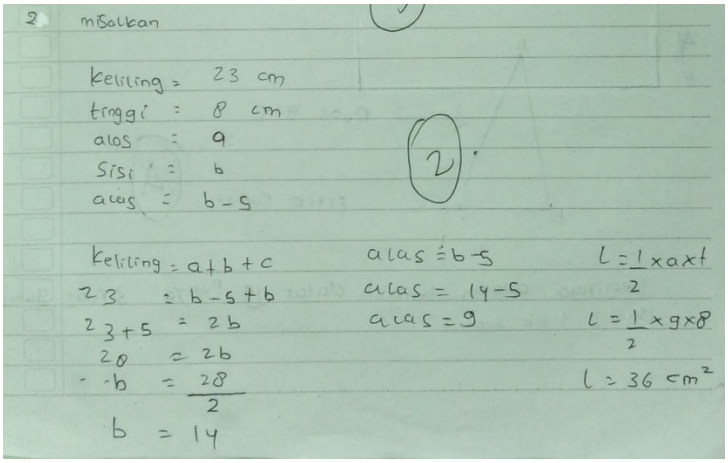

Figure 4. Student answers to the analyzing aspect

Figure 4 shows that students can analyze the problem well, but students are less careful in solving the problem. There are errors in applying the formula for the perimeter of a triangle. From the results of the data analysis, it can be seen that the highest aspect in critical thinking is interpreting, while the highest element in mathematical critical thinking is inferring. The increase in critical thinking skills in this research is included in the interpretation, evaluation, and inference aspects, while the increase in analysis is included in the medium category. To get someone used to using critical thinking skills, schools, in this case, teachers, can facilitate this by choosing an approach or learning model to encourage students to use critical thinking skills. Brain-Based Learning (BBL) learning can encourage students to think critically because the BBL approach encourages students to maximize the abilities of the left brain and right brain so that students feel relaxed, which will give rise to lots of critical thinking. According to [15], Brain-Based Learning can provide space for students to think freely without pressure and has a supportive learning environment. This is in line with the research results of [16], stating that the application of the Brain-Based Learning approach in learning thinking skills, especially critical

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thinking skills. Furthermore, [17] stated that the Brain-Based Learning (BBL) learning approach is a concept for creating learning based on efforts to empower students' brain potential. Based on these descriptions, it can be concluded that the application of the Brain-Based Learning learning model can improve students' critical thinking abilities.

Conclusion

The magnitude of life's challenges and competition now and in the future forces a person to always have the ability to think critically. When someone has to solve a problem, they will interpret, analyze, evaluate, and draw conclusions to be able to solve the problem. This thinking ability can be improved in mathematics learning by choosing an approach that activates left and right brain abilities. One of these learning lessons is brain-based learning. The advantage of brain-based learning is that students follow the brain's natural work so that it can provide a more complex understanding, this is suitable for helping students with their critical thinking skills. The results of data analysis in this study show that all aspects of students' mathematical critical thinking abilities (interpretation, analysis, evaluation and inference) have increased even though they are still in the medium and low categories. This research shows that the increase in students' analytical skills is in the low category. As an implication of this research, it is necessary to find out what factors cause an increase in students' low analytical skills and what needs to be done so that all aspects of students' critical mathematical abilities become high criteria.

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Stability and sensitivity analysis of SEIQR model on dynamics of SARS-CoV-2 with international in-out mobility in Indonesia

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Abstract. *In this paper, we modifiy the SEIQR model of SARS-CoV-2 dynamics by considering international in-and-out population mobility. The idea to modify this model stems from the government's efforts to overcome the spread of Covid-19 in Indonesia through restrictions on community activities, international travel restrictions, vaccinations and quarantine. This research aims to analyze the stability of the modified model and analyze the sensitivity of its parameters. As a result, the model has two critical points, namely an asymptotically stable critical point free of disease and a stable critical point for endemic conditions. Sensitivity analysis shows that the parameters related to natural death and birth rate of S has the greatest influence on the basic reproduction number. Parameters related to birth rate of S and increasing population through international in mobility are the parameters that have the most influence on E, I, and Q.*

Keyword: stability, sensitivity, SEIQR model, SARS-CoV-2, Covid-19

Introduction

The infection of the coronavirus or SARS-CoV-2 (*Severe Acute Respiratory Syndrome* 2) attacks the respiratory system and causes a disease called Covid-19 (*Coronavirus Disease* 2019). The first case was identified in Wuhan, Hubei Province, Cina in December 2019 [1]. Transmission of this virus occurs very quickly and has spread globally. In March 2020, the World Health Organization (WHO) designated Covid-19 as a global health emergency [2].

Indonesia is one of the countries affected by Covid-19 with6.723.546 people confirmed positive in January 2023 [3]. The Indonesian government is designing various efforts to suppress the surge in Covid-19. One of them is restrictions on public activities (PPKM) to avoid direct

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contact between communities and issues various regulations regarding international mobility during the Covid-19 pandemic.

Researchers from various fields also contributed to dealing with the Covid-19 pandemic in Indonesia. In the health sector, researchers observe the nature of the virus and it's dynamic. Mathematical scientists attempt to predict the spread of viruses, build models, and offer various intervention efforts related to these models. Mathematical model analysis of Covid-19 has been carried out by [4,5] by considering the existence of isolation classes and found that isolating infected individuals can reduce the risk of spreading Covid-19. Another study by [6] found that increased intervention and quarantine of infected individuals could slow the transmission of Covid-19.

In 2022, Sinaga et al. developed a SEIQR model for the spread of SARS-CoV-2. The model was developed by considering vaccination and international in-out mobility in Indonesia. The results show that the system will be stable after 60 months.

In mathematical modeling of disease spread, it is necessary to analyze which parameters influence the spread of disease. Sensitivity analysis examines variations in the model output caused by variations in the input (changes in parameter values). Sensitivity analysis on the spread of the disease has been carried out by [7] by analyzing factors that influence the transmission and treatment of cholera. Another study by [8,9] identified critical parameters that contribute to the spread of Covid-19 and found that parameters related to contact with susceptible and infected individuals were the most influential parameters.

The high spread rate of Covid-19 in Indonesia requires much more attention, it's necessary to analyze the model stability and parameter sensitivity. This research will analyze the SEIQR model of SARS-CoV-2 by modifying the model proposed by [10] using distribution data in Indonesia.

Methodology

This research uses a modified SEIQR model for the spread of SARS-CoV-2. The first step is to develop a modification scheme for the SEIQR model, determining critical points and stability types based on the Routh-Hurwitz Criteria. The next step is to determine the Basic Reproduction Number (R_0). Sensitivity analysis was carried out by determining the sensitivity expression and sensitivity index value for R_0 and critical endemic points of E, I, Q. Then, a numerical simulation was using data on Covid-19 cases in Indonesia published by the Indonesian Ministry of Health.

Results and Discussion

Modification of the SEIQR model for the spread of SARS-CoV-2

The SEIQR model for the spread of SARS-CoV-2 consists of five subpopulations, namely Susceptible (S), Exposed (E), Infected(I), Quarantined (Q), andRecovered (R). The model proposed by [10] considers the control of international in-out mobility. The SEIQR model modification scheme for the spread of SARS-CoV-2 shown in Figure 1.

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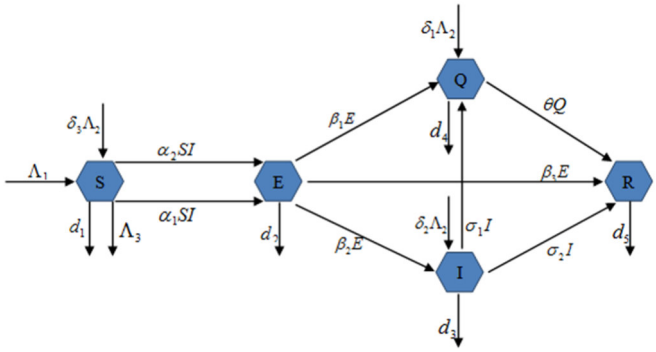

Figure 1. SEIQR model modification scheme

Based on the SEIQR model modification above, the differential equation system acquired as follows:

$$\frac{dS}{dt} = \Lambda_1 + \delta_3\Lambda_2 - \Lambda_3 - (\alpha_1 + \alpha_2)SI - d_1 S$$

$$\frac{dE}{dt} = (\alpha_1 + \alpha_2)SI - (\beta_1 + \beta_2 + \beta_3 + d_2)E$$

$$\frac{dI}{dt} = \delta_2\Lambda_2 + \beta_2 E - (\sigma_1 + \sigma_2 + d_3)I$$

$$\frac{dQ}{dt} = \delta_1\Lambda_2 + \beta_1 E + \sigma_1 I - (\theta + d_4)Q$$

$$\frac{dR}{dt} = \beta_3 E + \sigma_2 I + \theta Q - d_5 R$$

Table 1. Parameter definition

Parameter	Description	Parameter	Description
d_1, d_2, d_5	Natural death rate ofsusceptible, exposed, and recovered	β_2	Rate of exposed individuals who have infected
d_3, d_4	Death rate due to SARS-CoV-2 infection for subpopulation infected and quarantined	β_3	Rate of exposed individuals who have recovered
Λ_1	Susceptible addition parameter by birth	σ_1	Rate of infected individuals who have quarantined
Λ_2	Susceptible addition parameter through in international mobility	σ_2	Rate of infected individuals who have recovered
Λ_3	Susceptible reduction parameter through out international mobility	θ	Rate of quarantined individuals who have recovered
α_1	Number of contacts susceptible to infection from local subjects	δ_1	Proportion of the number of infected individuals from in international mobility and quarantined
α_2	Number of contacts susceptible to infection from international subjects	δ_2	Proportion of the number of infected individuals from in international mobility who are not quarantined
β_1	Rate ofexposed individuals who have quarantined	δ_3	Proportion of increase in population suspect by mobility in international

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The model has the disease-free critical point:

$$E_0 = (S_0^*, E_0^*, I_0^*, Q_0^*, R_0^*) = \left(\frac{\Lambda_1 + \delta_3\Lambda_2 - \Lambda_3}{d_1}, 0, 0, \frac{\delta_1\Lambda_2}{\theta + d_4}, \frac{\theta\delta_1\Lambda_2}{d_5(\theta + d_4)} \right)$$

where $\Lambda_1 + \Lambda_2 - \Lambda_3 \geq 0$ and $0 \leq \delta_2 \leq 1$ and the disease-endemic critical point $E_1(S^*, E^*, I^*, Q^*, R^*)$ with,

$$S^* = \frac{(\Lambda_1 + \delta_3\Lambda_2 - \Lambda_3)(\sigma_1 + \sigma_2 + d_3)}{(\alpha_1 + \alpha_2)(\delta_2\Lambda_2 + \beta_2 E^*) + d_1(\sigma_1 + \sigma_2 + d_3)}$$

$$I^* = \frac{\delta_2\Lambda_2 + \beta_2 E^*}{\sigma_1 + \sigma_2 + d_3}$$

$$Q^* = \frac{\delta_1\Lambda_2(\sigma_1 + \sigma_2 + d_3) + \sigma_1\delta_2\Lambda_2}{(\theta + d_4)(\sigma_1 + \sigma_2 + d_3)} + \frac{\beta_1(\sigma_1 + \sigma_2 + d_3) + \sigma_1\beta_2}{(\theta + d_4)(\sigma_1 + \sigma_2 + d_3)} E^*$$

$$R^* = \frac{\sigma_2\delta_2\Lambda_2(\theta + d_4) + \theta\delta_1\Lambda_2(\sigma_1 + \sigma_2 + d_3) + \theta\sigma_1\delta_2\Lambda_2}{d_5(\theta + d_4)(\sigma_1 + \sigma_2 + d_3)} + \frac{(\beta_3(\theta + d_4) + \theta\beta_1)(\sigma_1 + \sigma_2 + d_3) + \beta_2(\sigma_2(\theta + d_4) + \theta\sigma_1)}{d_5(\theta + d_4)(\sigma_1 + \sigma_2 + d_3)} E^*$$

$$E^* = \frac{-B \pm \sqrt{D}}{2A}$$

where $D = B^2 - 4AC > 0$, $-B \pm \sqrt{D} \geq 0$ and

$A = \beta_2(\alpha_1 + \alpha_2)(\beta_1 + \beta_2 + \beta_3 + d_2)$

$B = (\delta_2\Lambda_2(\alpha_1 + \alpha_2) + d_1(\sigma_1 + \sigma_2 + d_3))(\beta_1 + \beta_2 + \beta_3 + d_1) - \beta_2(\alpha_1 + \alpha_2)(\Lambda_1 + \delta_3\Lambda_2 - \Lambda_3)$

$C = -\delta_2\Lambda_2(\alpha_1 + \alpha_2)(\Lambda_1 + \delta_3\Lambda_2 - \Lambda_3)$

Stability analysis of critical points

Based on the SEIQR model, the Jacobian matrix at the disease-free critical point $J(E_0)$ shown in Equation (1).

$$J(E_0) = \begin{pmatrix} -d_1 & 0 & -\frac{(\alpha_1 + \alpha_2)(\Lambda_1 + \delta_3\Lambda_2 - \Lambda_3)}{d_1} & 0 & 0 \\ 0 & -(\beta_1 + \beta_2 + \beta_3 + d_2) & \frac{(\alpha_1 + \alpha_2)(\Lambda_1 + \delta_3\Lambda_2 - \Lambda_3)}{d_1} & 0 & 0 \\ 0 & \beta_2 & -(\sigma_1 + \sigma_2 + d_3) & 0 & 0 \\ 0 & \beta_1 & \sigma_1 & -(\theta + d_4) & 0 \\ 0 & \beta_3 & \sigma_2 & \theta & -d_5 \end{pmatrix} \quad (1)$$

By solving $|\lambda I - J(E_0)| = 0$, its obtained the characteristic equation in disease-free condition (Equation (2)).

$$(\lambda + d_1)(\lambda + d_5)(\lambda + \theta + d_4)r(\lambda) = 0 \quad (2)$$

with $r(\lambda) = a_2\lambda^2 + a_1\lambda + a_0$, where

$a_2 = 1$

$a_1 = \beta_1 + \beta_2 + \beta_3 + \sigma_1 + \sigma_2 + d_2 + d_3$

$$a_0 = (\beta_1 + \beta_2 + \beta_3 + d_2)(\sigma_1 + \sigma_2 + d_3) - \frac{\beta_2}{d_1}(\alpha_1 + \alpha_2)(\Lambda_1 + \delta_3\Lambda_2 - \Lambda_3)$$

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Based on the Routh-Hurwitz Criteria, the disease-free critical point is asymptotically stable if it was satisfied $d_1(\beta_1+\beta_2+\beta_3+d_2)(\sigma_1+\sigma_2+d_3)>\beta_2(\alpha_1+\alpha_2)(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)$.

The Jacobian matrix at the disease-endemic critical point $J(E_1)$ is as follows Equation (3).

$$\begin{pmatrix} -\frac{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)}{\sigma_1+\sigma_2+d_3}-d_1 & 0 & -\frac{(\alpha_1+\alpha_2)(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)(\sigma_1+\sigma_2+d_3)}{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)+d_1(\sigma_1+\sigma_2+d_3)} & 0 & 0 \\ \frac{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)}{\sigma_1+\sigma_2+d_3} & -\beta_1-\beta_2-\beta_3-d_2 & \frac{(\alpha_1+\alpha_2)(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)(\sigma_1+\sigma_2+d_3)}{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)+d_1(\sigma_1+\sigma_2+d_3)} & 0 & 0 \\ 0 & \beta_2 & -(\sigma_1+\sigma_2+d_3) & 0 & 0 \\ 0 & \beta_1 & \sigma_1 & -\theta-d_4 & 0 \\ 0 & \beta_3 & \sigma_2 & \theta & -d_5 \end{pmatrix} \quad (3)$$

By solving $|\lambda I-J(E_1)|=0$, its obtained the characteristic equation in disease-endemic condition on Equation (4).

$$(\lambda+d_5)(\lambda+\theta+d_4)s(\lambda)=0 \quad (4)$$

with $s(\lambda)=a_3\lambda^3+a_2\lambda^2+a_1\lambda+a_0$, where

$a_3=1$

$$a_2=\beta_1+\beta_2+\beta_3+\sigma_1+\sigma_2+d_1+d_2+d_3+\frac{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)}{\sigma_1+\sigma_2+d_3}$$

$$a_1=(\beta_1+\beta_2+\beta_3+d_2)(\sigma_1+\sigma_2+d_3)+\frac{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)}{\sigma_1+\sigma_2+d_3}+d_1-\frac{\beta_2(\alpha_1+\alpha_2)(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)(\sigma_1+\sigma_2+d_3)}{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)+d_1(\sigma_1+\sigma_2+d_3)}$$

$$a_0=(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)(\beta_1+\beta_2+\beta_3+d_2)+d_1(\beta_1+\beta_2+\beta_3+d_2)(\sigma_1+\sigma_2+d_3)$$
$$-\frac{d_1\beta_2(\alpha_1+\alpha_2)(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)(\sigma_1+\sigma_2+d_3)}{(\alpha_1+\alpha_2)(\delta_2\Lambda_2+\beta_2E^*)+d_1(\sigma_1+\sigma_2+d_3)}$$

Based on the Routh-Hurwitz Criteria, the disease-endemic critical point is stable if it was satisfied $a_1>0$, $a_2>0$ and $a_1a_2>a_3a_0$.

Sensitivity analysis for basic reproduction number

The Basic Reproduction Number (R_0) is the expected number of infections per unit of time determined using the next-generation matrix approach in the subpopulations *E*, *I*, and *Q*. Suppose φ is the increased rate of infection; ψ is the rate of disease movement, death, and recovery, so the vectors φ and ψ obtained as follows:

$$\varphi=\begin{pmatrix}(\alpha_1+\alpha_2)SI\\ \delta_2\Lambda_2+\beta_2E\\ \delta_1\Lambda_2+\beta_2E+\sigma_1I\end{pmatrix} \text{ and } \psi=\begin{pmatrix}(\beta_1+\beta_2+\beta_3+d_2)E\\ (\sigma_1+\sigma_2+d_3)I\\ (\theta+d_4)Q\end{pmatrix}$$

Linearization of vectors φ and ψ produces vectors *F* and *V* as follows:

$$F=\begin{pmatrix}0 & (\alpha_1+\alpha_2)S & 0\\ \beta_2 & 0 & 0\\ \beta_1 & \sigma_1 & 0\end{pmatrix} \text{ and } V=\begin{pmatrix}\beta_1+\beta_2+\beta_3+d_2 & 0 & 0\\ 0 & \sigma_1+\sigma_2+d_3 & 0\\ 0 & 0 & \theta+d_4\end{pmatrix}$$

By solving the equation $K=FV^{-1}$ and substituting the disease-free critical point (E_0), it obtained R_0 which is the largest eigenvalue of the matrix *K*, that is on Equation (5).

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$$R_0 = \max[\lambda_1, \lambda_2] = \sqrt{\frac{\beta_2(\alpha_1+\alpha_2)(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)}{d_1(\beta_1+\beta_2+\beta_3+d_2)(\sigma_1+\sigma_2+d_3)}} \quad (5)$$

Then, the sensitivity expression for R_0 is determined by satisfying the following equation [13]:

$$C_p^{R_0} = \frac{\partial R_0}{\partial p} \times \frac{p}{R_0}$$

where p is the parameter that will be tested for sensitivity to R_0. Thus, the following sensitivity expression of R_0 is shown in Table 3.

Table 3. Sensitivity expression of R_0

Parameter	Sensitivity Expression	Parameter	SensitivityExpression
d_1	$-\frac{1}{2}$	β_1	$-\frac{\beta_1}{2(\beta_1+\beta_2+\beta_3+d_2)}$
d_2	$-\frac{d_2}{2(\beta_1+\beta_2+\beta_3+d_2)}$	β_2	$\frac{\beta_1+\beta_3+d_2}{2(\beta_1+\beta_2+\beta_3+d_2)}$
d_3	$-\frac{d_3}{2(\sigma_1+\sigma_2+d_3)}$	β_3	$-\frac{\beta_3}{2(\beta_1+\beta_2+\beta_3+d_2)}$
d_4	0	σ_1	$-\frac{\sigma_1}{2(\sigma_1+\sigma_2+d_3)}$
d_5	0	σ_2	$-\frac{\sigma_2}{2(\sigma_1+\sigma_2+d_3)}$
Λ_1	$\frac{\Lambda_1}{2(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)}$	θ	0
Λ_2	$\frac{\delta_3\Lambda_2}{2(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)}$	δ_1	$-\frac{\delta_1\Lambda_2}{2(\Lambda_1+(1-\delta_1-\delta_2)\Lambda_2-\Lambda_3)}$
Λ_3	$-\frac{\Lambda_3}{2(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)}$	δ_2	$-\frac{\delta_2\Lambda_2}{2(\Lambda_1+(1-\delta_1-\delta_2)\Lambda_2-\Lambda_3)}$
α_1	$\frac{\alpha_1}{2(\alpha_1+\alpha_2)}$	δ_3	$\frac{\delta_3\Lambda_2}{2(\Lambda_1+\delta_3\Lambda_2-\Lambda_3)}$
α_2	$\frac{\alpha_2}{2(\alpha_1+\alpha_2)}$		

Sensitivity analysis for endemic critical point E

The sensitivity expression for the endemic critical point E is determined by satisfying the following equation [13]:

$$C_p^{E^*} = \frac{\partial E^*}{\partial p} \times \frac{p}{E^*}$$

where p is the parameter that will be tested for sensitivity to E^*. Thus, the following sensitivity expression of E^* is as follows Table 4.

Table 4. Sensitivity expression of E^* (P: Parameter)

P	Sensitivity Expression	P	Sensitivity Expression

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d_1	$\frac{d_1}{2AE^*}\left(-\frac{\partial B}{\partial d_1}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial d_1}\right)-\frac{d_1}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial d_1}$	β_1	$\frac{\beta_1}{2AE^*}\left(-\frac{\partial B}{\partial \beta_1}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \beta_1}\right)-\frac{\beta_1}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \beta_1}$
d_2	$\frac{d_2}{2AE^*}\left(-\frac{\partial B}{\partial d_2}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial d_2}\right)-\frac{d_2}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial d_2}$	β_2	$\frac{\beta_2}{2AE^*}\left(-\frac{\partial B}{\partial \beta_2}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \beta_2}\right)-\frac{\beta_2}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \beta_2}$
d_3	$\frac{d_3}{2AE^*}\left(-\frac{\partial B}{\partial d_3}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial d_3}\right)-\frac{d_3}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial d_3}$	β_3	$\frac{\beta_3}{2AE^*}\left(-\frac{\partial B}{\partial \beta_3}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \beta_3}\right)-\frac{\beta_3}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \beta_3}$
d_4	$\frac{d_4}{2AE^*}\left(-\frac{\partial B}{\partial d_4}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial d_4}\right)-\frac{d_4}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial d_4}$	σ_1	$\frac{\sigma_1}{2AE^*}\left(-\frac{\partial B}{\partial \sigma_1}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \sigma_1}\right)-\frac{\sigma_1}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \sigma_1}$
d_5	$\frac{d_5}{2AE^*}\left(-\frac{\partial B}{\partial d_5}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial d_5}\right)-\frac{d_5}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial d_5}$	σ_2	$\frac{\sigma_2}{2AE^*}\left(-\frac{\partial B}{\partial \sigma_2}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \sigma_2}\right)-\frac{\sigma_2}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \sigma_2}$
Λ_1	$\frac{\Lambda_1}{2AE^*}\left(-\frac{\partial B}{\partial \Lambda_1}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \Lambda_1}\right)-\frac{\Lambda_1}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \Lambda_1}$	θ	$\frac{\theta}{2AE^*}\left(-\frac{\partial B}{\partial \theta}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \theta}\right)-\frac{\theta}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \theta}$
Λ_2	$\frac{\Lambda_2}{2AE^*}\left(-\frac{\partial B}{\partial \Lambda_2}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \Lambda_2}\right)-\frac{\Lambda_2}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \Lambda_2}$	δ_1	$\frac{\delta_1}{2AE^*}\left(-\frac{\partial B}{\partial \delta_1}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \delta_1}\right)-\frac{\delta_1}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \delta_1}$
Λ_3	$\frac{\Lambda_3}{2AE^*}\left(-\frac{\partial B}{\partial \Lambda_3}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \Lambda_3}\right)-\frac{\Lambda_3}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \Lambda_3}$	δ_2	$\frac{\delta_2}{2AE^*}\left(-\frac{\partial B}{\partial \delta_2}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \delta_2}\right)-\frac{\delta_2}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \delta_2}$
α_1	$\frac{\alpha_1}{2AE^*}\left(-\frac{\partial B}{\partial \alpha_1}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \alpha_1}\right)-\frac{\alpha_1}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \alpha_1}$	δ_3	$\frac{\delta_3}{2AE^*}\left(-\frac{\partial B}{\partial \delta_3}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \delta_3}\right)-\frac{\delta_3}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \delta_3}$
α_2	$\frac{\alpha_2}{2AE^*}\left(-\frac{\partial B}{\partial \alpha_2}\pm\frac{1}{2\sqrt{D}}\frac{\partial D}{\partial \alpha_2}\right)-\frac{\alpha_2}{2A^2E^*}(-B\pm\sqrt{D})\frac{\partial A}{\partial \alpha_2}$		

Sensitivity analysis for endemic critical point I

The sensitivity expression for the endemic critical point I is determined by satisfying the following equation [13]:

$$C_p^{I^*}=\frac{\partial I^*}{\partial p}\times\frac{p}{I^*}$$

where p is the parameter that will be tested for sensitivity to I^*. Thus, the following sensitivity expression of I^* is on Table 5.

Table 5. Sensitivity expression of I^*

Parameter	Sensitivity Expression	Parameter	Sensitivity Expressions
d_1	$\frac{\beta_2 d_1}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial d_1}$	β_1	$\frac{\beta_1\beta_2}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial \beta_1}$
d_2	$\frac{\beta_2 d_2}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial d_2}$	β_2	$\frac{\beta_2E^*}{\delta_2\Lambda_2+\beta_2E^*}+\frac{\beta_2^2}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial \beta_2}$
d_3	$\frac{\beta_2 d_3}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial d_3}-\frac{d_3}{\sigma_1+\sigma_2+d_3}$	β_3	$\frac{\beta_2\beta_3}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial \beta_3}$
d_4	$\frac{\beta_2 d_4}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial d_4}$	σ_1	$\frac{\beta_2\sigma_1}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial \sigma_1}-\frac{\sigma_1}{\sigma_1+\sigma_2+d_3}$
d_5	$\frac{\beta_2 d_5}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial d_5}$	σ_2	$\frac{\beta_2\sigma_2}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial \sigma_2}-\frac{\sigma_2}{\sigma_1+\sigma_2+d_3}$

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Λ_1	$\frac{\beta_2\Lambda_1}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\Lambda_1}$	θ	$\frac{\beta_2\theta}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\theta}$
Λ_2	$\frac{\delta_2\Lambda_2}{\delta_2\Lambda_2+\beta_2E^*}+\frac{\beta_2\Lambda_2}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\Lambda_2}$	δ_1	$\frac{\beta_2\delta_1}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\delta_1}-\frac{\Lambda_2\delta_1}{\delta_2\Lambda_2+\beta_2E^*}$
Λ_3	$\frac{\beta_2\Lambda_3}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\Lambda_3}$	δ_2	$\frac{\Lambda_2\delta_2}{\delta_2\Lambda_2+\beta_2E^*}+\frac{\beta_2\delta_2}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\delta_2}$
α_1	$\frac{\beta_2\alpha_1}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\alpha_1}$	δ_3	$\frac{\beta_2\delta_3}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\delta_3}-\frac{\Lambda_2\delta_3}{\delta_2\Lambda_2+\beta_2E^*}$
α_2	$\frac{\beta_2\alpha_2}{\delta_2\Lambda_2+\beta_2E^*}\frac{\partial E^*}{\partial\alpha_2}$		

Sensitivity analysis for endemic critical point Q

Sensitivity expression for the endemic critical point of Q is determined by satisfying the following equation [13]:

$$C_p^{Q^*}=\frac{\partial Q^*}{\partial p}\times\frac{p}{Q^*}$$

where p is the parameter that will be tested for the sensitivity to Q^*. Thus, the following sensitivity expression of Q^* is on Table 6.

Table 6. Sensitivity expression of Q^*

Parameter	Sensitivity Expression
d_1	$\frac{d_1(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial d_1}$
d_2	$\frac{d_2(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial d_2}$
d_3	$\frac{d_3(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial d_3}$ $-\frac{d_3(\sigma_1\delta_2\Lambda_2+E^*\sigma_1\beta_2)}{(\sigma_1+\sigma_2+d_3)(\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2))}$
d_4	$\frac{d_4(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial d_4}-\frac{d_4}{\theta+d_4}$
d_5	$\frac{d_5(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial d_5}$
Λ_1	$\frac{\Lambda_1(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\Lambda_1}$
Λ_2	$\frac{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}$ $+\frac{\Lambda_2(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\Lambda_2}$
Λ_3	$\frac{\Lambda_3(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\Lambda_3}$

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α_1	$\frac{\alpha_1(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\alpha_1}$
α_2	$\frac{\alpha_2(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\alpha_2}$
β_1	$\frac{E^*\beta_1(\sigma_1+\sigma_2+d_3)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}$ $+\frac{\beta_1(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\beta_1}$
β_2	$\frac{E^*\sigma_1\beta_2}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}$ $+\frac{\beta_2(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\beta_2}$
β_3	$\frac{\beta_3(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\beta_3}$
σ_1	$\frac{\sigma_1(\delta_2\Lambda_2+E^*\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}$ $-\frac{\sigma_1^2(\delta_2\Lambda_2+E^*\beta_2)}{(\sigma_1+\sigma_2+d_3)(\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2))}$ $+\frac{\sigma_1(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\sigma_1}$
σ_2	$\frac{\sigma_2(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\sigma_2}$ $-\frac{\sigma_1\sigma_2(\delta_2\Lambda_2+E^*\beta_2)}{(\sigma_1+\sigma_2+d_3)(\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2))}$
θ	$\frac{\theta(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\theta}-\frac{\theta}{\theta+d_4}$
δ_1	$\frac{\Lambda_2\delta_1(\theta+d_4)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}$ $+\frac{\delta_1(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\delta_1}$
δ_2	$\frac{\Lambda_2\sigma_1\delta_2}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}$ $+\frac{\delta_2(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\delta_2}$
δ_3	$\frac{\delta_3(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}\frac{\partial E^*}{\partial\delta_3}$ $-\frac{\delta_3\Lambda_2(2\sigma_1+\sigma_2+d_3)}{\Lambda_2(\delta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\delta_2)+E^*(\beta_1(\sigma_1+\sigma_2+d_3)+\sigma_1\beta_2)}$

Numerical Simulation

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The numerical simulation carried out using the Runge-Kutta 4th Order method and software MATLAB R2015a, using data on the spread of Covid-19 in Indonesia (March 2020-August 2022) by the Ministry of Health [3].

Table 7. Parameter value

Parameter	Value	Refference	Parameter	Value	Refference
d_1	0.000001	Assumed	α_1	0.042135	Assumed
d_2	0.000001	Assumed	α_2	0.042135	Assumed
d_3	0.000063	Estimated	β_1	0.000950	Estimated
d_4	0.000063	Estimated	β_2	0.005023	Estimated
d_5	0.000001	Assumed	β_3	0.001679	Assumed
Λ_1	0.017070	Assumed	σ_1	0.000950	Assumed
Λ_2	0.001105	Assumed	σ_2	0.001679	Assumed
Λ_3	0.000933	Estimated	θ	0.001679	Estimated

Numerical simulation using initial value: $S_0 = 6.777$, $E_0 = 0$, $I_0 = 1.528$, $Q_0 = 1.311$, $R_0 = 0.081$ with parameter value based on Table 7 and $\delta_1 = 0.25$, $\delta_2 = 0.25$, $\delta_3 = 0.5$, so it obtained the following graph:

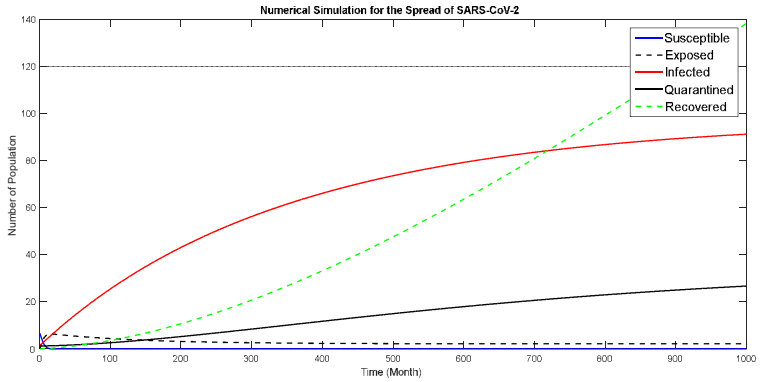

Figure 2. Stability of SEIQR model for the spread of SARS-CoV-2

The graph in Figure 2 shows that the number of individuals in Subpopulation S will continue to decrease because the infection process continues so that Subpopulations E and I temporarily increase and then decrease for quite a long time. The number of infections is very high because the positive effect of vaccination is not yet significant. This means that the infection process in the March 2020-August 2022 was very high. The decrease in infection cases occurred because Subpopulation Q increased thereby reducing the infection process, then Subpopulation R increased due to natural immunity and vaccination.

The numerical simulation of sensitivity analysis based on the sensitivity index value of the most sensitive parameter obtained by substituting the parameter value in the basic reproduction number (R_0), E^*, I^*, and Q^* as follows:

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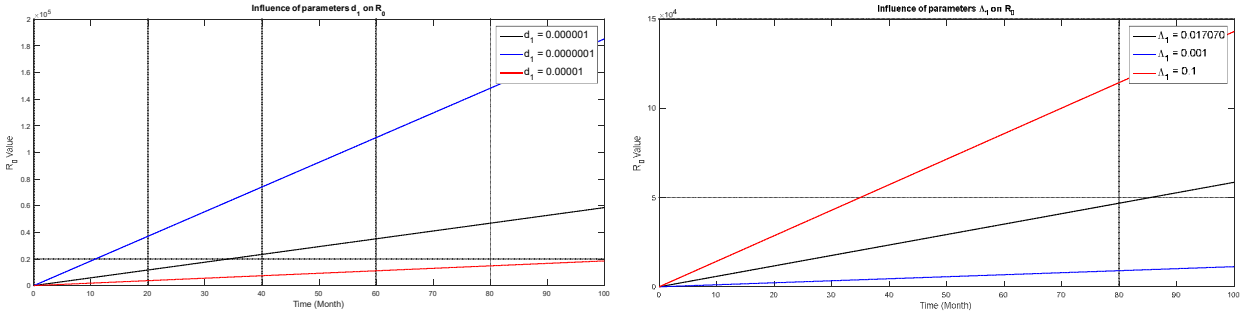
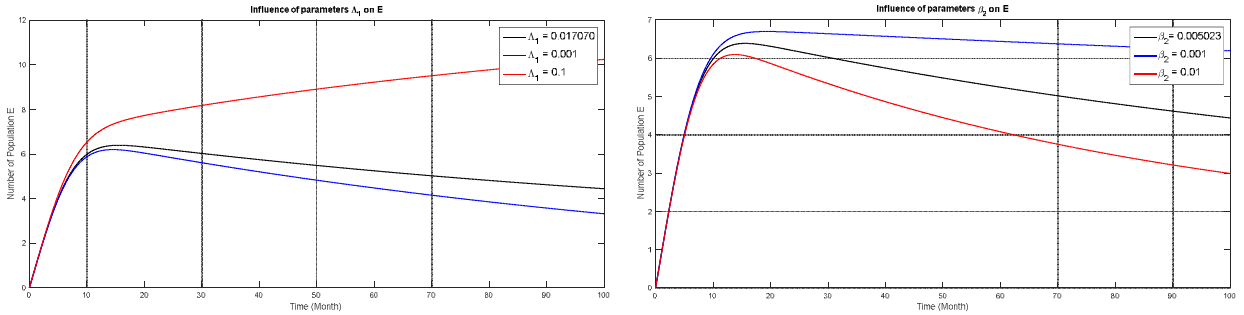


(a) (b)

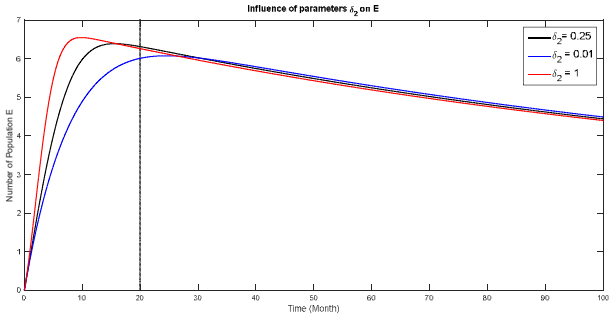
Figure 3. Sensitivity analysis graph of R_0

The graph in Figure 3 shows the relationship between parameter d_1, Λ_1 and the value of R_0 where (a) parameter d_1 has a negative relationship to R_0, and (b) parameter Λ_1 has a positive relationship to R_0.

The numerical simulation of the sensitivity analysis of E^* is shown in the following figure:



(a) (b)



(c)

Figure 4. Sensitvity analysis graph of E^*

The graph in Figure 4 shows the relationship between parameter Λ_1, β_2, δ_2 and the value of E^* where (a) parameter Λ_1 has a positive relationship to E^*, (b) parameter β_2 has a negative relationship to E^*, (c) parameter δ_2 has a negative relationship to E^*.

The numerical simulation of the sensitivity analysis of I^* is shown in the following figure 5

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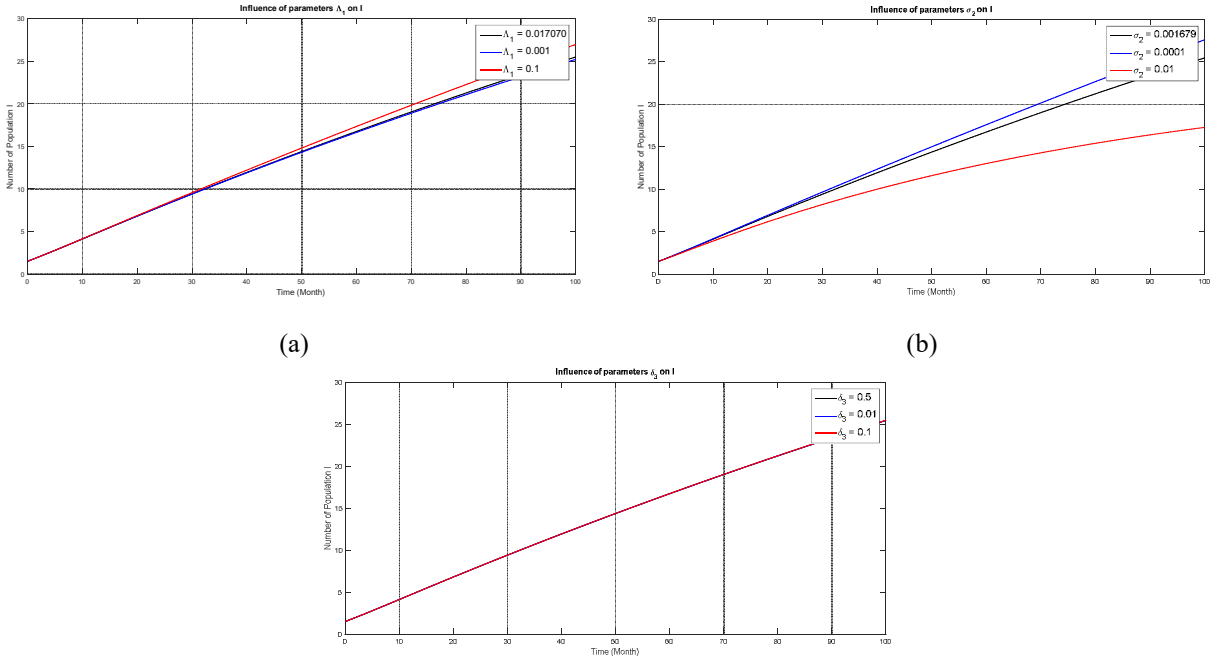

Figure 5. Sensitivity analysis graph of I^*

The graph in Fig.5 shows the relationship between parameter Λ_1, σ_2, δ_3 and the value of I^* where (a) parameter Λ_1 has a positive relationship to I^*, (b) parameter σ_2 has a negative relationship to I^*, and (c) parameter δ_3 has a negative relationship to I^*.

The numerical simulation of the sensitivity analysis of Q^* is shown in the following figure:

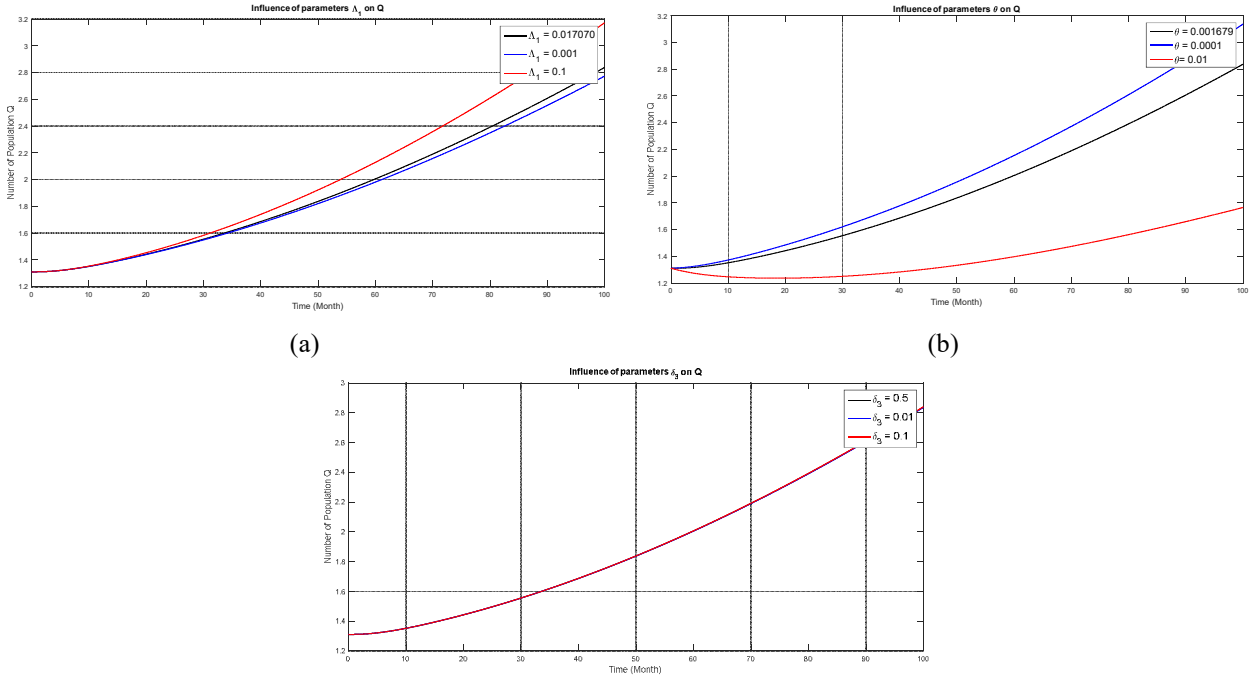

Figure 6. Sensitivity analysis graph of Q^*

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The graph in Figure 6 shows the relationship between parameter Λ_1, θ, δ_3 and the value of Q^* where (a) parameter Λ_1 has a positive relationship to Q^*, (b) parameter θ has a negative relationship to Q^*, and (c) parameter δ_3 has a positive relationship to Q^*.

Conclusion

The modified SEIQR model for the spread of SARS-CoV-2 has two critical points, namely the disease-free and the disease-endemic critical points. These two critical points will be stable if they satisfy the conditions for the inequality parameter values. Numerical simulation show that the system will be stable for quite a long time. Furthermore, the sensitivity analysis shows that parameters related to natural death and birth rate of *S* is the most sensitive parameters on changing the value of R_0. Sensitivity analysis also showed that the parameters related to birth rate of *S* and the proportion of increase population *S* by in international mobility are the most sensitive parameters that change the value of *E*, *I*, and *Q*.

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Generalization of Cramer's rule

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Abstract. *Systems of linear equations of the form $Ax = b$ can have a single solution, an infinite number of solutions, or no solutions. The solution of the system of linear equations $Ax = b$, $x \in R^n$, $\boldsymbol{b} \in R^m$ and $n \geq m$ where $A = (a_{ij})_{m \times n}$ is a real matrix in a single solution when $m = n$ and $det\ (A) \neq 0$, can be obtained by applying Cramer's rule. Cramer's rule provides a precise way to solve a system of linear equations with as many equations as unknowns. That is, for the solution of a system with a rectangular matrix, given that the coefficient matrix is invertible. Cramer's rule offers a quick and simple answer. In this study, we will apply this method to a $n \geq m$ system of linear equations. By generalizing Cramer's rule, the system of linear equations $Ax = b$ $A = (a_{ij})_{m \times n}$ can be solved not only when the matrix A is square, but also when the matrix A is not square.*

Keywords: system of linear equations, solution, square matrix, Cramer's rule, generalize.

Introduction

In linear algebra, Cramer's method is a formula that can be used to solve systems of linear equations with as many equations as the number of variables and is valid when the system has a single solution. This formula states the solution using the determinant of the coefficient matrix and the determinant of another matrix obtained by replacing one of the columns of the coefficient matrix with a vector on the right side of the equation.

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Cramer's method was introduced by the Swiss mathematician Gabriel Cramer (1704–1752), who in 1750 published this rule for any number of variables. The advantage of Cramer's method is that it gives us the final formula for the solution. Cramer's rule can be used for various theorem proofs in linear algebra.

A solution for the linear system is a sequence of n real numbers $(s_1, s_2, \cdots, s_3)$_which when replaced in the linear system's equations, all becomes true statements. The primary goal for these structures is finding the set of solutions to this system, that is, to find all n-tuple $(x_1, x_2, \cdots, x_n)$ that satisfy $Ax = b$. A general system of linear equations belongs into one of the following categories: (i) it has exactly one solution, (ii) it has infinitely many solutions or (iii) it has no solution

Problems that often arise in finding solutions to systems of linear equations are usually related to the size of the matrix, the larger the matrix, the more complicated the calculations, so appropriate methods are needed. Solving a system of linear equations with m equations and n variables can use determinants [1, 2], Gauss and Gauss-Jordan elimination, while for n equations and n variables you can use several methods, including Gauss Elimination,Gauss-Jordan Elimination, Inverse Matrix Method, Cramer's Rule, LU Decomposition (top-down triangle factorization) and Crout Decomposition.

The system of linear equations $A\boldsymbol{x} = \boldsymbol{b}$, $\boldsymbol{x} \in R^n$, $\boldsymbol{b} \in R^m$ and $n \geq m$ where $A = (a_{ij})_{m \times n}$ is a real matrix has a single solution when $m = n$ and $det\ (A) \neq 0$.The solution to the system of linear equations can be found using Cramer's rules [3] [4] [5]. Burgstahler [6] claimed that the system of linear equations $A\boldsymbol{x} = \boldsymbol{b}$ with a square matrix A can be represented as a linear combination of system solutions, which is known as a generalization of simple Cramer's rules. In its development, a generalization of Cramer's simple rule is used to determine the solution to the system of linear equations $A\boldsymbol{x} = \boldsymbol{b}$ where $A = (a_{ij})_{m \times n}$ which means not only when the matrix A is square, but also when the matrix A is not square. cage, in this case $n > m$ [1].

Definition 1

A system of equations that has at least one solution is called consistent. Otherwise, it is called inconsistent [7].

Definition 2

Gaussian elimination is the process of determining the solution to a system of linear equations by changing the coefficient matrix of the system into an upper triangular matrix by performing a number of elementary row operations [8].

Definition 3

Gauss-Jordan elimination is the process of determining the solution to a system of linear equations by changing the coefficient matrix of the system into an upper triangular matrix and a lower triangular matrix (diagonal matrix) by performing a number of row operations [8].

Definition 4

Assume $A = (a_{ij})$ be a $n \times n$ matrix. The determinant of A (written $det\ (A)$ or $|A|$) is defined as $\det(A) = |A| = \sum(\pm)a_{1j_1}a_{2j_2} \cdots a_{nj_n}$, where the sum includes all permutations $j_1, j_2, \cdots, j_n$ of

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the set $S = \{1,2,\cdots,n\}$. The sign is interpreted as $+$ or $-$ depending on whether the permutation $j_1, j_2, \cdots, j_n$ is even or odd [9].

Definition 5

Consider $A = (a_{ij})$ to be a $n \times n$ matrix. Let M_{ij} be the $(n-1) \times (n-1)$ submatrix of A produced by eliminating the i^{th} row and j^{th} column of A. The determinant $det\ (M_{ij})$ is known as the minor of a_{ij}. The cofactor A_{ij} of a_{ij} is defined as $A_{ij} = (-1)^{i+j} det\ (M_{ij})$ [9].

Theorem 1

Let $A = (a_{ij})$ be an $n \times n$ matrix. Then for each $1 \leq i \leq n$,

$$det\ det\ (A) = a_{i1}A_{i1} + a_{i2}A_{i2} + \cdots + a_{in}A_{in}$$ (Expansion of $det\ (A)$ about the i^{th} row)

and for each $1 \leq j \leq n$,

$$det\ det\ (A) = a_{1j}A_{1j} + a_{2j}A_{2j} + \cdots + a_{nj}A_{nj}$$ (Expansion of $det\ (A)$ about the j^{th} column)

Definition 6

(Adjoint of Matrix)

Let $A = (a_{ij})$ be a $n \times n$ matrix. The adjoint of A is the matrix whose $(i,j)^{th}$ element is the cofacktor A_{ij} of a_{ij} (the transpose of the matrix of cofactors), so refer to [7] :

$$adj(A) = [A_{11}\ A_{21}\ \cdots\ A_{n1}\ A_{12}\ A_{22}\ \cdots\ A_{n2}\ \vdots\ A_{1n}\ \vdots\ A_{2n}\ \ddots\ \cdots\ \vdots\ A_{nn}\ ]$$

Definition 7

A linear transformation f from R^n into R^m is a function assigns a unique vector $f(x)$ in R^m to each x in R^n such that:

(a). $f(x+y) = f(x) + f(y)$, for every x and y in R^n.

(b). $f(kx) = kf(x)$ for every x in R^n and every scalar k

If $n = m$, the linier transformation $f : R^n \to R^m$ is called a linier operator on R^n .

Theorem 2

Refer to [7], let $f : R^n \to R^m$ be a linier transformation defined by $f(x) = Ax$, $x \epsilon R^n$, where A is a $m \times n$ matrix.

(1). f is one-to-one if and only if $rank(A) = n$

(2). f is onto if and only if $rank(A) = m$

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Lemma 3

Consider the vector space R^m and R^n, and let $f_A : R^m \to R^n$ and $f_{A^T} : R^n \to R^m$ the adjoint operator, then the following statemen holds

(1). $Rang(A) = R^n \leftrightarrow \exists \gamma > 0$ such that $\|A^T z\|_{R^m} \geq \gamma \|z\|_{R^n}$, $z \epsilon R^n$.

(2). $\underline{Rang(A)} = R^n \leftrightarrow Ker(A^T) = \{0\} \leftrightarrow A^T$ is $1-1$.

Results and discussion

Cramer's rule can be extended to systems of m equations and n variables. The key to Cramer's Rule is to replace the variable column of interest with the constant column and calculate the determinants. Several theorems express the findings of the study.

Theorem 4

Consider the following linear system of m equations with n unknowns

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &= c_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &= c_2 \\ \vdots + \vdots + \cdots + \vdots &= \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n &= c_m \end{aligned}$$

Let $A = [a_{ij}]$ be the coefficient matrix, $c = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_m \end{bmatrix}$. If $\det(A) \neq 0$, then

$$x_1 = \frac{\det(A_1)}{\det(A)}, x_2 = \frac{\det(A_2)}{\det(A)}, \cdots, x_n = \frac{\det(A_n)}{\det(A)} \qquad (1)$$

is a solution for the system $\boldsymbol{Ax = c}$, where A_j is the matrix obtained from A by replacing the j^{th} column of A by $\boldsymbol{c}$.

Proof.

Perhatikan sistem persamaan linier $\boldsymbol{Ax = c}$

$$\boldsymbol{x = A^{-1}c}$$

$$\begin{bmatrix} \boldsymbol{x_1} \\ \boldsymbol{x_2} \\ \vdots \\ \boldsymbol{x_n} \end{bmatrix} = \frac{\mathbf{1}}{\boldsymbol{det(A)}} \boldsymbol{(adj(A))}$$

$$\begin{bmatrix} \boldsymbol{x_1} \\ \boldsymbol{x_2} \\ \vdots \\ \boldsymbol{x_n} \end{bmatrix} = \frac{\mathbf{1}}{\boldsymbol{det(A)}} \begin{bmatrix} A_{11} & A_{21} & \cdots & A_{m1} \\ A_{12} & A_{22} & \cdots & A_{m2} \\ \vdots & \vdots & \ddots & \vdots \\ A_{1n} & A_{2n} & \cdots & A_{mn} \end{bmatrix} \boldsymbol{c}$$

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$$\begin{bmatrix} \boldsymbol{x_1} \\ \vdots \\ \boldsymbol{x_j} \\ \vdots \\ \boldsymbol{x_n} \end{bmatrix} = \begin{bmatrix} \frac{A_{11}}{\boldsymbol{det(A)}} & \frac{A_{21}}{\boldsymbol{det(A)}} & \cdots & \frac{A_{m1}}{\boldsymbol{det(A)}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\boldsymbol{A_{1j}}}{\boldsymbol{det(A)}} & \frac{\boldsymbol{A_{2j}}}{\boldsymbol{det(A)}} & \cdots & \frac{\boldsymbol{A_{mj}}}{\boldsymbol{det(A)}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\boldsymbol{a_{1n}}}{\boldsymbol{det(A)}} & \frac{A_{2n}}{\boldsymbol{det(A)}} & \cdots & \frac{A_{mn}}{\boldsymbol{det(A)}} \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_m \end{bmatrix}$$

This means that

$$x_j = \frac{A_{1j}}{\det(A)} c_1 + \frac{A_{2j}}{\det(A)} c_2 + \cdots + \frac{A_{mj}}{\det(A)} c_m \text{ for } 1 \le j \le n,$$

Where

$$A_j = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j-1} & c_1 & a_{1j+1} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2j-1} & c_2 & a_{2j+1} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mj-1} & c_m & a_{mj+1} & \cdots & a_{mn} \end{bmatrix}$$

If we evaluate $\det(A_j)$ be expanding a bout the j^{th} column, we find that

$$\det(A_j) = A_{1j}c_1 + A_{2j}c_2 + \cdots + A_{mj}c_m$$

Hence we get

$$x_j = \frac{\det(A_j)}{\det(A)}, \text{ for } j = 1,2,\cdots,n.$$

Example. Find a solution to the system

$$\begin{aligned} x_1 + 2x_2 + x_3 + 3x_4 &= 4 \\ x_1 - 2x_2 + 4x_3 + 5x_4 &= 2 \\ 2x_1 + 3x_2 + x_3 + 4x_4 &= 1 \end{aligned}$$

Based on Cramer's rules, the system of equations can be expressed in the form $\boldsymbol{Ax} = \boldsymbol{b}$, with a coefficient matrix $\boldsymbol{A} = \begin{bmatrix} 1 & 2 & 1 & 3 \\ 1 & -2 & 4 & 5 \\ 2 & 3 & 1 & 4 \end{bmatrix}$ and constant vector $\boldsymbol{b} = \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix}$. Using Radic's definition we get,

$$\det(A) = \sum_{1 \le 2 \le 3 \le 4} (-1)^{r+s} det \begin{bmatrix} 1 & 2 & 1 & 3 \\ 1 & -2 & 4 & 5 \\ 2 & 3 & 1 & 4 \end{bmatrix} = -10$$

$A_1 = \begin{bmatrix} 4 & 2 & 1 & 3 \\ 2 & -2 & 4 & 5 \\ 1 & 3 & 1 & 4 \end{bmatrix}$, $A_2 = \begin{bmatrix} 1 & 4 & 1 & 3 \\ 1 & 2 & 4 & 5 \\ 2 & 1 & 1 & 4 \end{bmatrix}$, $A_3 = \begin{bmatrix} 1 & 2 & 4 & 3 \\ 1 & -2 & 2 & 5 \\ 2 & 3 & 1 & 4 \end{bmatrix}$ dan $A_4 = \begin{bmatrix} 1 & 2 & 1 & 4 \\ 1 & -2 & 4 & 2 \\ 2 & 3 & 1 & 1 \end{bmatrix}$

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In the same way we obtain :

$$\det(A_1) = \sum_{1\le2\le3\le4} (-1)^{r+s} det \begin{bmatrix} 4 & 2 & 1 & 3 \\ 2 & -2 & 4 & 5 \\ 1 & 3 & 1 & 4 \end{bmatrix} = 62 \implies x_1 = \frac{\det(A_1)}{\det(A)} = {}^{62}/_{-10}$$

$$\det(A_2) = \sum_{1\le2\le3\le4} (-1)^{r+s} det \begin{bmatrix} 1 & 4 & 1 & 3 \\ 1 & 2 & 4 & 5 \\ 2 & 1 & 1 & 4 \end{bmatrix} = -34 \implies x_2 = \frac{\det(A_2)}{\det(A)} = {}^{34}/_{10}$$

$$\det(A_3) = \sum_{1\le2\le3\le4} (-1)^{r+s} det \begin{bmatrix} 1 & 2 & 4 & 3 \\ 1 & -2 & 2 & 5 \\ 2 & 3 & 1 & 4 \end{bmatrix} = -49 \implies x_3 = \frac{\det(A_3)}{\det(A)} = {}^{49}/_{10}$$

$$\det(A_4) = \sum_{1\le2\le3\le4} (-1)^{r+s} det \begin{bmatrix} 1 & 2 & 1 & 4 \\ 1 & -2 & 4 & 2 \\ 2 & 3 & 1 & 1 \end{bmatrix} = 2 \implies x_4 = \frac{\det(A_4)}{\det(A)} = {}^{2}/_{-10}$$

A solution given by Cramer's rule is $({}^{62}/_{-10}, {}^{34}/_{10}, {}^{49}/_{10}, {}^{2}/_{-10})$

Theorem 5 (Generalization of Cramer's rule)

The system $\boldsymbol{Ax} = \boldsymbol{b}$ is solvable for any $b \epsilon R^n$ and A and $m \times n$ if and only if $\det(AA^T) \neq 0$. Furthermore, one solution for this equation is $x = A^T(AA^T)^{-1}b$, where A^T is the transpose of A. This answer also agrees with the Cramer's rule formula for $n = m$. In actuality, this formula is as follows:

$$x_j = \sum_{i=1}^{m} a_{ij} \frac{\det((AA^T)_i)}{\det(AA^T)}, j = 1,2,\cdots,n.$$

Where $(AA^T)_i$ is the matris obtained by replacing the entries in the j^{th} column of AA^T by the entries in the matrix $b = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_m \end{bmatrix}$.

Proof .

The matrix A represents a linear transformation $T_A: R^m \to R^n$ and its transpose A^T produce a linear transformation, adjoint operator, such that$T_{A^T}: R^m \to R^n$. If the operator A is onto, i.e, $Range\ (A) = R^n$, the system $\boldsymbol{Ax} = \boldsymbol{b}$ is solvable for all $b \epsilon R^m$. Hence, there exist $\gamma > 0$ such that $\|A^T z\|_{R^m} \geq \gamma \|z\|_{R^n}$, $z \epsilon R^n$. Therefore $(AA^T z, z) \geq \gamma^2 \|z\|_{R^n}^2$, $z \epsilon R^n$. This implies that T_{AA^T} : $R^n \to R^n$, and $Rang(AA^T) = R^n$ and $Ker(AA^T) = \{0\}$. According to Theorem 2 and Lemma 3, AA^T is one to one. Since AA^T is a $n \times n$ matrix, then $\det(AA^T) \neq 0$.

Suppose now that $\det(AA^T) \neq 0$. Then $(AA^T)^{-1}$ exist given $b \epsilon R^n$ we can see that $x = A^T(AA^T)^{-1}b$ is a solution of $= \boldsymbol{b}$.

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Now, because z=(AAT)(-1) b is the unique solution to the equation (AAT)z=b, we can deduce from Theorem 4 (Cramer's rule) that:

Now, because $z = (AA^T)^{-1}b$ is the unique solution of the equation $(AA^T)z = b$, we can deduce from Theorem 4 (Cramer's rule) that:

$$z_1 = \frac{\det((AA^T)_1)}{\det(AA^T)}, z_2 = \frac{\det((AA^T)_2)}{\det(AA^T)}, \cdots, z_n = \frac{\det((AA^T)_n)}{\det(AA^T)}.$$

Where $(AA^T)_i$ is the matrix formed by substituting the items in the j^{th} column of AA^T with entries from matrix $b = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_m \end{bmatrix}$.

Then, the solution $x = A^T(AA^T)^{-1}b = A^T z$ of $\boldsymbol{Ax} = \boldsymbol{b}$ can be written as follows

$$x_k = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \begin{bmatrix} \frac{\det((AA^T)_1)}{\det(AA^T)} \\ \frac{\det((AA^T)_2)}{\det(AA^T)} \\ \vdots \\ \frac{\det((AA^T)_n)}{\det(AA^T)} \end{bmatrix} = \begin{bmatrix} \sum_{j=1}^{n} a_{j,1} \frac{\det((AA^T)_j)}{\det(AA^T)} \\ \sum_{j=1}^{n} a_{j,2} \frac{\det((AA^T)_j)}{\det(AA^T)} \\ \vdots \\ \sum_{j=1}^{n} a_{j,m} \frac{\det((AA^T)_j)}{\det(AA^T)} \end{bmatrix}$$

Example Find a solution to the system

$$2x + 3y - 2z = 4 \; -6x - 8y + 6z = 1$$

Solution.

Let x be a solution to $Ax = b$ (if it exists)

Coeffisient matrix of the system is $A = [\,2\;\;3\;\;-2\;\;-6\;\;-8\;\;6\,]$, $det\,det\,(A) = 4$ and $b = [4\;1\,]$ is the constant vector.

$AA^T = [\,2\;\;3\;\;-2\;\;-6\;\;-8\;\;6\,][\,2\;\;-6\;\;3\;\;-8\;\;-2\;\;6\,] = [\,17\;\;-48\;\;-48\;\;136\,]$ and $det\,det\left(AA^T\right) = 8$.

$$(AA^T)_1 = [4\;\;-48\;1\;\;136\,] \Longrightarrow det\,(AA^T)_1 = 594$$

$$(AA^T)_2 = [\,17\;4\;\;-48\;1\,] \Longrightarrow det\,(AA^T)_2 = 209$$

$$x = \frac{a_{11}det\,((AA^T)_1)}{det\,(AA^T)} + \frac{a_{21}det\,((AA^T)_2)}{det\,(AA^T)} = \frac{2 \times 592}{8} + \frac{-6 \times 209}{8} = \frac{-70}{8}$$

$$y = \frac{a_{12}det\,((AA^T)_1)}{det\,(AA^T)} + \frac{a_{22}det\,((AA^T)_2)}{det\,(AA^T)} = \frac{3 \times 592}{8} + \frac{-8 \times 209}{8} = \frac{104}{8} = 13$$

$$z = \frac{a_{13}det\,((AA^T)_1)}{det\,(AA^T)} + \frac{a_{23}det\,((AA^T)_2)}{det\,(AA^T)} = \frac{-2 \times 592}{8} + \frac{6 \times 209}{8} = \frac{70}{8}$$

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Conclusion

In a system of linear equations, if the number of equations is less than the number of variables, then the system of equations has infinitely many solutions. Solving a system of linear equations using the Cramer Method provides a solution in a special form.

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Survival analysis of cox proportional hazard regression model in coronary heart patients by using exact method

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Abstract. *Survival analysis is a statistical procedure used to analyze data by considering the time of events from the beginning to the end of observations. The data used in this analysis is the survival time data, which serves as the independent variable. This study will perform survival analysis using the Cox proportional hazard model with an exact method approach for cases of coronary heart disease patients at RSUP H Adam Malik Medan. Survival analysis is commonly used to assess survival probabilities, one of which is through the Cox proportional hazard regression model. The exact method is the most relevant approach to handling tied events, enabling researchers to conduct more accurate and reliable analyses while considering the non-proportionality of hazards over time. According to the research report on national health outcomes, coronary heart disease is Indonesia's second leading cause of death. In North Sumatra, the prevalence of coronary heart disease in 2013 was 0.5%, which increased to 1.3% in 2018. The study's results indicate that coronary heart disease patients over 40 years have a 1.0101 times longer recovery rate compared to patients under 40.*

Keywords: survival analysis, cox proportional hazard, exact method, coronary heart disease

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Introduction

Survival analysis is a statistical procedure used to analyze data while considering the time of events from the beginning to the end of observation. The data used in this analysis are survival time data, which serve as the independent variables [2]. Survival analysis is commonly employed to assess survival probabilities, such as through the Cox Proportional Hazard regression model. The Cox Proportional Hazard regression model allows researchers to measure the impact of various independent variables, including age, gender, blood pressure, dyslipidaemia, smoking history, and diabetes mellitus, contributing to death or heart attacks.

The exact method in this research is used to address changing risk behaviour patterns over time, known as event ties, as the proportional hazard assumption is not always met. The exact method is the most relevant approach to deal with event ties, enabling researchers to perform more accurate and reliable analyses by considering the non-proportional hazard over time.

This research will conduct a survival analysis using the Cox Proportional Hazard model with the exact method approach for cases involving coronary heart disease (CHD) patients. Coronary heart disease is one of the primary cardiovascular diseases and remains a leading cause of death in many countries, including Indonesia, presenting significant challenges to healthcare services. This condition develops when there is an accumulation of atherosclerotic plaques in the coronary arteries, resulting in the obstruction of blood flow that supplies oxygen to the heart muscles, ultimately leading to heart attacks [5].

According to the National Health Research report, CHD ranks as Indonesia's second-highest cause of death. In North Sumatra, the prevalence of coronary heart disease increased from 0.5% in 2013 to 1.3% in 2018 [4].

Based on this description, the author aims to investigate the factors influencing the length of hospitalization for Coronary Heart Disease patients at RSUP H. Adam Malik Medan using the Cox Proportional Hazard model with the exact method approach.

Literature review

Survival analysis

Survival analysis is a statistical procedure used to analyze data while considering the time to events from the beginning to the end of observation. The data used in this analysis primarily consists of survival times, which serve as the independent variable [2]. Time is defined as the observation period in units such as days, weeks, months, or years, and events are defined as occurrences like relapse, recovery, or death.

Survival function

The survival function $S(t)$ is a probability function of a random variable representing the probability that the random variable's survival time exceeds a given time $t(t > 0)$. It is defined as follows:

$$S(t) = 1 - P(T \leq t) = \int_t^{\infty} F(t) = 1 - F(t) \quad (1)$$

Probability density function

The Probability Density Function (PDF) is often referred to as the probability that an individual will die or experience an event at a specific moment within the time interval from t to $t + \Delta t$. The probability density function $f(t)$ is formulated as follows [3]:

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$$f(t) = \lim_{\Delta t \to 0} \frac{P(t < T < (t + \Delta t))}{\Delta t} = \lim_{\Delta t \to 0} \frac{F(t + \Delta t) - F(t)}{\Delta t} \quad (2)$$

Based on Equation (2) , it can be derived to Equation (3).

$$f(t) = \frac{d(F(t))}{dt} = F'(t) \quad (3)$$

Hazard function

This is a fundamental quantity in survival analysis. In this context, it is assumed that individuals have survived up to the beginning of a small time interval $(t, t + \Delta t)$, and the hazard represents the instantaneous probability of an individual failing within this small time interval, $(t, t + \Delta t)$ given that the individual has survived up to time *t*. It is defined as Equation (4).

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t \le T < t + \Delta t \mid T \ge t)}{\Delta t} \quad (4)$$

Cox proportional hazard model

The Cox Proportional Hazard model is named after its developer, and it's called the Cox model because the hazard functions of different individuals are proportional, meaning the ratio of the hazard functions for two different individuals remains constant [3]. The Cox model can be expressed in Equation (5).

$$h(t, \mathbf{X}) = h_0(t) \exp\left(X_1\beta_1 + X_2\beta_2 + \cdots + X_p\beta_p\right) = h_0(t) \exp\left(\sum_i^p X_i\beta_i\right) \quad (5)$$

Estimating parameters using the exact

The exact partial likelihood function for parameter estimation is in Equation (6).

$$L(\boldsymbol{\beta}) = \prod_{i=1}^{r} \frac{\exp\left(\sum_{l \in D(t_i)} \sum_{j=1}^{p} x_{lj}(t_i)\beta_j\right)}{\sum_{l \in R(t_i)} \exp\left(\sum_{j=1}^{p} x_{lj}(t_i)\beta_j\right)} \quad (6)$$

From the equation above, we obtain the log-likelihood function as in Equation (7).

$$\begin{aligned} \ln L(\boldsymbol{\beta}) &= \prod_{i=1}^{r} \frac{\exp\left(\sum_{l \in D(t_i)} \sum_{j=1}^{p} x_{lj}(t_i)\beta_j\right)}{\sum_{l \in R(t_i)} \exp\left(\sum_{j=1}^{p} x_{lj}(t_i)\beta_j\right)} \\ &= \prod_{i=1}^{r} \begin{bmatrix} \sum_{l \in D(t_i)} \sum_{j=1}^{p} x_{lj}(t_i)\beta_j \\ -\ln\left(\sum_{l \in R(t_i)} \exp\left(\sum_{j=1}^{p} x_{lj}(t_i)\beta_j\right)\right) \end{bmatrix} \end{aligned} \quad (7)$$

Parameter testing

Parameter testing is conducted using likelihood ratio tests and Wald tests [1]. These tests are performed to determine whether the independent variables significantly impact the model.

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Ratio likelihood test

Hypothesis

$H_0: \beta_1 = \beta_2 = \cdots = \beta_p = 0$

$H_1:$ at least one $\beta_j \neq 0$, with $j = 1,2,3, \ldots, p$

Likelihood ratio test statistic shown in Equation (8) and rejection criteria of H_0 shown in Equation (9).

$$G^2 = -2[\ln L_R - \ln L_f] \tag{8}$$

$$G \geq \chi^2_{(\alpha,p)} \text{ or } p - value \leq \alpha = 0.05 \tag{9}$$

Wald test

Hypothesis

$H_0: \beta_j = 0$

$H_1: \beta_j \neq 0;\ j = 1,2,3, \ldots, p$

Statistic test shown in Equation (10) and rejection criteria of H_0 shown in Equation (11).

$$|W| = \left| \frac{\hat{\beta}_J}{SE\ \beta_j} \right| \tag{10}$$

$$W > Z_{\alpha/2} \text{ or } p - value \leq \alpha = 0.05 \tag{11}$$

The best model

The best model is the one with the lowest AIC value. The formula to calculate AIC shown in Equation (12).

$$AIC = -2l\left(\hat{\beta}\right) + 2df \tag{12}$$

Hazard ratio

The hazard ratio indicates an increase or decrease in the risk for individuals subjected to a specific treatment [3]. It is expressed in the following Equation (13).

$$\widehat{HR} = \frac{\widehat{h_0}(t) exp \sum_j^p X_j^* \beta_j}{\widehat{h_0}(t) exp \sum_j^p X_j \beta_j} \tag{13}$$

Coronary heart disease (CHD)

Coronary Heart Disease (CHD) is a cardiovascular disease and a leading cause of death in many countries, including Indonesia. It presents a serious challenge to healthcare services. This condition develops when atherosclerotic plaques accumulate in the coronary arteries, leading to a blockage of blood flow that supplies oxygen to the heart muscle, resulting in heart attacks [5]. According to the National Health Research

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report, CHD is the second leading cause of death in Indonesia, and in North Sumatra, the prevalence of coronary heart disease increased from 0.5% in 2013 to 1.3% in 2018 [4].

Results and Discussion

Descriptive analysis

The sample size in this study is 171 samples, with 59 censored samples, and the remaining 112 samples are uncensored data.

The cox proportional hazard regression model

The Cox Proportional Hazard regression model examines the impact of independent variables on the dependent variable. In this study, the independent variables used are gender (X_1), age (X_2), history of hypertension (X_3), diabetes mellitus (X_4), and smoker (X_5). The initial Cox Proportional Hazard regression model with the exact method (Equation (13)).

$$h(t,X) = h_0\,(t)exp(0.14757\,X_1 + 0.80519X_2 + 0.07047X_3 + 0.18815X_4 + 0.27626X_5) \quad (13)$$

Testing of the proportional hazard assumption

This study's formal testing of the proportional hazard assumption was conducted using a Goodness of Fit test employing Schoenfeld residuals.

Table 1. Assumption testing using R Studio

	Chisq	df	p
Gender	0.85651	1	0.35
Age	1.04847	1	0.31
Hypertension	1.57568	1	0.21
Diabetes	0.18002	1	0.67
Smoker	0.00281	1	0.96
GLOBAL	4.03417	5	0.54

At a significance level of α=0.05, it can be concluded that there is no correlation between the Schoenfeld residuals and survival time. This implies that all variables suspected to influence the survival time of coronary heart disease patients satisfy the proportional hazard assumption.

Parameter Testing

Ratio likelihood test

Hypothesis:

$H_0: \beta_2 = 0$

$H_1: \beta_j \neq 0$

Likelihood ratio test statistic:

$$G = -2[-\ln(471.1682) + \ln(254.0687)]$$

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$$= -2\left[-6.155 + 5.537\right]$$

$$= -2\left[-0.617\right] = 1.234$$

If H_0 is rejected, which is the case when the p-value $p - value \leq \alpha$ is $0.101 < 0.05$, it can be concluded that there is an independent variable that has an effect on the dependent variable.

Wald test

Hypothesis

$H_0: \beta_2 = 0$

$H_1: \beta_2 \neq 0$

Statistic test:

$$|W| = \left|\frac{\hat{\beta}_2}{SE(\hat{\beta}_2)}\right| = \left|\frac{0.8447}{0.3285}\right| = 2.571$$

H_0 is rejected because $p - value \leq 0.05$ that $0.101 < 0.05$. Based on the calculation of $W > Z_{a/2}$, it is found that $2.571 < 0.05$. Therefore, it can be concluded that there is an independent variable supporting H2 and, as a result, the age variable has an influence on the length of hospitalization for coronary heart disease patients at RSUP H Adam Malik Medan.

The best model

By using backward elimination based on significant variables in the model.

Table 2. Model for all steps with AIC

NO	Model	AIC
1	$X_1 + X_2 + X_3 + X_4 + X_5$	508.77
2	$X_1 + X_2 + X_4 + X_5$	506.77
3	$X_1 + X_2 + X_5$	505.08
4	$X_2 + X_5$	503.67
5	X_2	502.54

The smallest AIC value is found in the fourth model. Therefore, it is decided that the best model is the fifth model, which includes the variable X_2, as it has the smallest AIC value, which is 502.54. The final equation shown in Equation (14).

$$h_t(t) = h_0(t)\exp(0.8447X_2) \tag{14}$$

Interpretation

The interpretation of the hazard ratio indicates that for coronary heart disease patients above 40 years of age, their patient recovery rate is 1.0101 times longer

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compared to patients under 40. This suggests that older patients tend to take a slightly longer time to recover compared to younger patients.

Conclusion

Based on the results of the study on Cox Proportional Hazard regression using the Exact method with survival data for coronary heart disease patients at RSUP H Adam Malik Medan, the following conclusions can be drawn:

1. In the application of data using the Exact method, the final Cox Proportional Hazard model obtained is as follows:
$$h_t(t) = h_0(t)\exp(0.8447X_2)$$
2. Based on the smallest AIC value criterion, the best Cox Proportional Hazard regression model with the Exact method is the 5th model, which includes the variable age.

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Descriptive analysis of the cost of living in urban areas in Indonesia

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Abstract. *The cost of living shows the value of a household's expenditure in one month. A study of the cost of living can provide an overview of the lives of residents in an area, including household income, types of household expenses, and so on. This information can be used as a consideration in making regional development plans. This research aims to describe the distribution of the cost of living in urban areas in Indonesia and its characteristics. The results show that the highest and lowest cost of living for individuals is continued Jakarta with a value of IDR3,540,951,- per month, and Kotabaru City with a value of IDR1,421,793,- per month. Whereas, for the expence of living per household, the highest and lowest cities are Bekasi by IDR13,680,544,- per month, and Kotabaru City with a value of IDR5,962,998,- per month. The average household expenditure in urban areas is highest for the food, beverage, and tobacco group category, reaching 30.59%, followed by the housing, water, electricity, and household fuel group at 18.33%. On the other, for the education group, the average percentage of household expenditure per city is 3.68%. The highest household income is Jakarta for IDR21,433,656,- per month, and the lowest in Kotabaru City with a value of IDR5,962,998,- per month.*

Keywords: cost of living, household, expenses, income, urban area

Introduction

The cost of living is the amount of expenditure required to meet the needs of a decent living for individuals and households. As time goes by, accompanied advances in technology, changes in people's income, changes in the quality and quantity of goods or services, and attitude and behavior (lifestyle) encourage changes in people's living costs from time to time. Regularly, Badan Pusat Statistik Republik Indonesia (BPS-RI, a State High Institution that handles state

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statistical data issues) conducts Cost of Living Surveys (SBH) to update the latest data regarding the Cost of Living for Indonesian people, especially in urban areas. Currently, BPS is holding SBH in 2022, so the last SBH publication issued by BPS is SBH implemented in 2018 [1]. Apart from that, SBH is also an important variable used in calculating the Consumer Price Index (CPI) where the CPI describes changes in prices of a group of goods and services that are consumed by the public and the level of inflation or deflation.

Cost of living is related to consumptive household expenditure and non-consumptive household expenditure, both for payments and business. Other things related to the cost of living are income, number of family members, and place of residence. Studies on the cost of living need to maximize its use, such as consideration for the government in determining policies related to the community directly (wages, prices of commodities, etc.) or as information for the community about socio-economic conditions in an area. Besides that, when someone intends to move from one area to another, it is very important to estimate the environmental conditions in the destination, including the cost of living in the destination area, so that this does not become an obstacle [2].

Studies on the cost of living can be descriptively or inferentially. Descriptive analysis means describing how the characteristics of the distribution of the cost-of-living data in various urban areas in Indonesia follow the data as is without intending to test hypotheses. This quantitative descriptive study usually includes commonly used statistical measures [3]. What is the highest and lowest cost of living, the average cost of living in urban areas, what variables contribute most to the cost of living, and other characteristics? Meanwhile, inferential analysis is related to testing several hypotheses according to needs. This research aims to describe the characteristics of cost-of-living data in terms of statistical studies.

Research Methods

The research method is descriptive quantitative analysis using secondary data from BPS-RI. The population in this study were all urban households in Indonesia. Descriptive analysis is a method that can used as a physical description of something. In food analysis, descriptive analysis widely provides an overview of sensory attributes that can include color, appearance, shape, taste, and texture [4]. In other words, Descriptive analysis aims to provide a comprehensive picture of a data set, such as variable distribution, central tendency, and dispersion [5].

The samples in the research were households domiciled in 90 cities in Indonesia as per the data in SBH 2018, namely: Banda Aceh, Meulaboh, Lhokseumawe, Medan, Sibolga, Pematang Siantar, Padangsidempuan, Gunungsitoli, Padang, Bukittinggi, Pekanbaru, Tembilahan, Dumai , Jambi, Bungo, Palembang, Lubuklinggau, Bengkulu, Bandar Lampung, Metro, Pangkal Pinang, Tanjung, Pandan, Tanjung Pinang, Batam, Jakarta, Bandung, Bogor, Sukabumi, Cirebon, Bekasi, Depok, Tasikmalaya, Semarang, Cilacap, Purwokerto, Kudus, Surakarta, Tegal, Yogyakarta, Surabaya, Jember, Banyuwangi, Sumenep, Kediri, Malang, Probolinggo, Madiun, Serang, Tangerang, Cilegon, Denpasar, Singaraja, Mataram, Bima, Kupang, Waingapu, Maumere, Pontianak, Sintang, Singkawang, Palangka Raya, Sampit, Banjarmasin, Kotabaru, Tanjung, Samarinda, Balikpapan, Tanjung Selor, Tarakan, Manado, Kotamobagu, Palu, Luwuk, Makassar, Bulukumba, Watampone, Pare-pare, Palopo, Kendari, Bau-Bau, Gorontalo, Mamuju, Ambon, Ternate, Tual, Manokwari, Sorong, Jayapura, Merauke and Timika.

The response variable in this research is the cost of living, while the dependent variables

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are X1 for food, beverage, and tobacco groups. X2 for clothing and footwear group. X3 for housing, water, electricity, and household fuel groups. X3 for groups of equipment. X4 for routine household maintenance. X5 for health group. X6 for transport group. X7 for information, communication, and financial services group. X8 for recreation, sports, and cultural groups. X9 for educational groups. X10 for food and beverage/restaurant provision group. X11 for group personal care and other services.

RESULTS AND DISCUSSION

Living costs relate to all costs incurred by a person or household in living their life for one month. In the cost of living survey conducted by the government in 2018, the cost of living was grouped into the cost of living for consumptive and non-consumptive expenses [1]. Consumption expenditure includes food, beverage, tobacco, clothing, footwear, housing, water, electricity, household fuel, groups of equipment, tools and routine household maintenance, health, transport, information, communication, recreation, sports, educational, group personal care, and other services. Meanwhile, non-consumptive expenses can be in the form of investments or gifts to other parties. This research uses expenditure data that is only consumptive in nature.

The first step in this descriptive analysis section, for all sample data which includes the values of the response variable Y (cost of living) and the independent variables X which follow as mentioned in the previous section, the statistical measures consisting of mean, maximum, minimum and standard deviation for each variable criterion are shown in Table 1.

Table 1. Descriptive statistics for cost-of-living response variable (Y) and independent variables (X)

	N	Minimum	Maximum	Mean	Std. Deviation
Cost-of-living	90	4906804.00	13680544.00	7281336.278	1743791.224
X1	90	1305246.00	3274693.00	2184352.578	410806.5723
X2	90	247588.00	2921312.00	728557.1444	711915.6833
X3	90	607514.00	3100285.00	1354192.567	473195.4262
X4	90	176446.00	974851.00	385012.0556	129794.8807
X5	90	76939.00	404266.00	177044.7333	65491.63724
X6	90	477780.00	1918142.00	881643.2889	283771.8024
X7	90	204133.00	850956.00	419300.2444	133484.2716
X8	90	50117.00	341717.00	131753.4444	53452.87920
X9	90	50117.00	973575.00	280583.2556	184648.3339
X10	90	249727.00	1325765.00	587979.5333	209072.8977
X11	90	256958.00	920768.00	457408.6444	130022.9130
X12	90	5962998.00	21433656.00	10304948.49	2864304.440
Valid N (listwise)					

The statistical measure of the mean can provide an idea of how data is distributed around the mean value. The mean is obtained by adding up all the data values and dividing it by the number of data [7, 8].

The cost of living, as the cost of living for one family (household) with the number of dependents living together in the family, it can also be expressed in the form of the cost of living per individual (per capita). Based on data collected from [1], several facts related to the cost of urban living in Indonesia are presented in several tables and diagrams below [8].

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Table 2. The City with the Highest Average Cost of Living per Capita in Indonesia (SBH 2018)

City	Cost of Living per capita (*Rupiah*)
Jakarta	3.540.951
Bekasi	3.336.718
Surabaya	3.150.412
Depok	2.833.035
Bogor	2.526.540
Tangerang	2.369.605
Malang	2.286.911
Bandung	2.236.367
Makassar	2.230.784
Balikpapan	2.185.066

Table 2 shows that the highest cost of living for one person is in the city of Jakarta at IDR. 3,540,951,- which was followed by other cities, namely Bekasi, Surabaya, Depok, Bogor, and so on. This table also shows that around 80% of the cities with the highest average cost of living (individual) are on the island of Java, followed by cities on the island of the eastern region of Indonesia. On the other hand, of the 90 cities in the research sample, if they are sorted from lowest to highest based on the average cost of living per capita, it can be seen in Table 3.

Table 3. The City with the Lowest Average Cost of Living per Capita in Indonesia (SBH 2018)

City	Cost of Living per capita (*Rupiah*)
Maumere	1.082.224
Waingapu	1.122.781
Sibolga	1.153.952
Mamuju	1.209.650
Bulukumba	1.240.906
Tual	1.243.807
Cilacap	1.258.155
Purwokerto	1.293.600
Lubuklinggau	1.299.041
Sumenep	1.328.867

Table 3 shows that the lowest cost of living for individuals in urban areas is IDR1,082,224,- namely in Maumere City. The cities with the lowest cost of living are occupied by Waingapu, Sibolga, Mamuju, Bulukumba, and so on. While many highest cities are on the island of Java, this is not the case with the cities with the lowest cost of living, which is in the eastern regions of Indonesia.

As stated at the beginning of this chapter, apart from the cost of living for individuals, the cost of living is also calculated per household. This calculation is closely related to how many people live and live together in the household. Diagram 1 visually presents the position of several cities in Indonesia in terms of the average cost of living per household.

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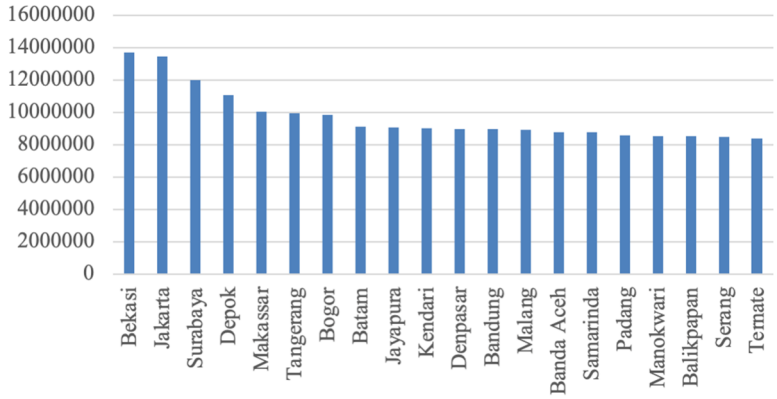

Figure 1. City with the highest average cost of living per household in Indonesia (SBH, 2018)

Figure 1 shows that for the cost of living per household, Bekasi City occupies the highest position by an amount reaching more than IDR. 13,500,000,-. Respectively, Jakarta and Surabaya are in the 2nd and 3rd highest positions. When compared with city data with average expenditure per capita (per person) in Table 2, it appears that there has been an exchange of positions between these cities. This fact can occur due to differences in the average number of family members living together in a household for a city in Figure 2.

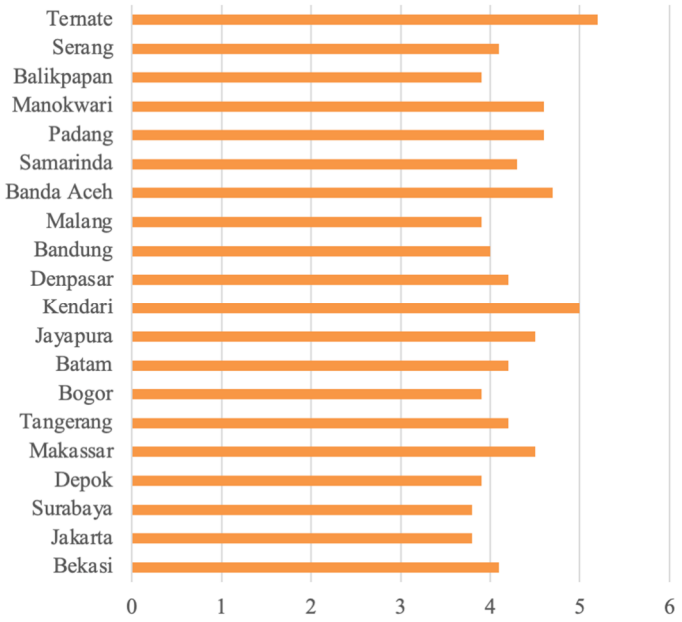

Figure 2. City with the average number of family members per household in Indonesia (SBH, 2018)

Based on Figure 2, it shows that the average number of family members per household for urban areas in Indonesia is in the range of 3 – 6 people (complete data attached). The diagram shows that the average number of children per family in urban areas is around 1 – 4 children. In Figure 1 and Figure 2, the city with the highest average number of family members is Ternate, and the cities with the lowest average number of family members are Jakarta and Surabaya.

Another thing that is closely related to the cost of living is income. Expenditures are

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ready if income is available, so it is necessary to pay attention to the income of residents in urban areas. An overview of the average income per household in several cities in Indonesia can be showed in Figure 3.

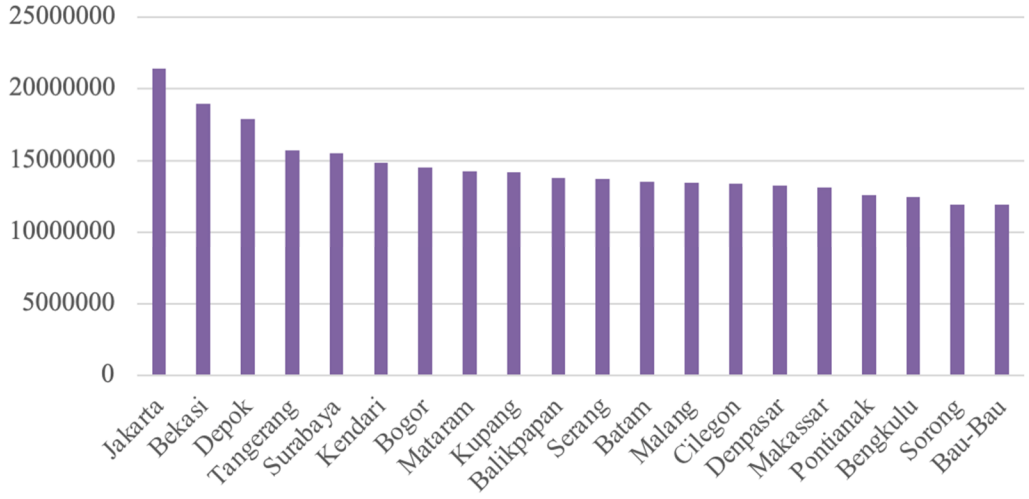

Figure 3. City with the highest average income per household in Indonesia (SBH, 2018)

The distribution of 20 cities with the highest average household income for urban areas in Indonesia is shown in Figure 3. It appears Jakarta is again in the highest position by an average household income of more than IDR. 21,000,000,-. it is the same with previous information regarding average expenditure, household, and per capita. Jakarta is in the 20 highest cities in Indonesia. However, several cities are not in the highest category in terms of expenditure, but in terms of income, these cities are in the highest category, such as Sorong City, Bau-bau, and several other cities.

On the other hand, in terms of the lowest average income per household for urban areas in Indonesia, it is shown in Figure 4.

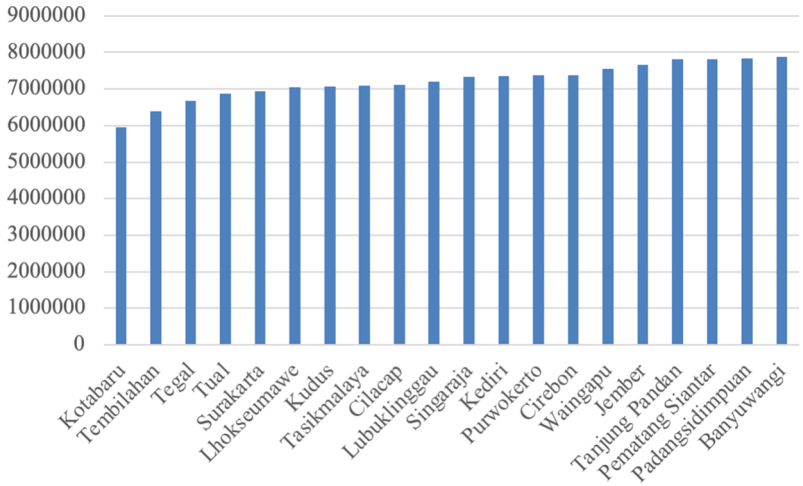

Figure 4. City with the Lowest Average Household Income in Indonesia (SBH, 2018)

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Figure 4 provides an overview of the distribution of 20 cities in Indonesia that have the lowest average income per household in urban areas in Indonesia. The minimum average income is Kotabaru, less than IDR. 6,000,000,- every month, followed by Tembilahan, Tegal, Tual, and other cities shown in Figure 4. Based on Figure 4 and Table 3, there is synchronization between the city with the lowest average expenditure and the city with the minimum average income, where several cities are in both categories, such as Tual City, Lhokseumawe, Surakarta, and several other cities. This fact shows that income is one of the factors that influences expenditure in macroeconomic theory [6]. In general, the average living cost expenditure is IDR 1,747,300 per month for one person, while the average living cost expenditure for one household is IDR 7,281,336 per month.

Descriptive analysis of the cost of living in terms of its relationship (proportion) with the independent variables, it found that the highest percentage of the cost of living for the needs of the food, drink, and tobacco group reached 30.59%, followed by the housing, water, electricity, and household fuel group at 18.33%. On the other hand, for the education group, the average percentage of household expenditure per city is 3.68%, in detail can be seen in Table 4.

Table 4. Average of percentage of independent variable X to response variable Y (cost of living)

Percentage of independent variable X to response variable Y										
X1	**X2**	**X3**	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**
30,59	0,00	18,33	5,26	8,31	11,99	5,71	1,79	3,68	8,03	6,34

Where X1 is food, beverage, and tobacco groups. X2 is the clothing and footwear group. X3 is housing, water, electricity, and household fuel groups. X3 is groups of equipment. X4 is routine household maintenance. X5 is a health group. X6 is the transport group. X7 is an information, communication, and financial services group. X8 is recreation, sports, and cultural groups. X9 is educational groups. X10 is a food and beverage/restaurant provision group. X11 is group personal care and other services.

Conclusions

Descriptive analysis of the cost of living for urban areas in Indonesia includes the average cost of living per person in urban areas, the average cost of living per household in urban areas, the city with the highest cost of living per person, the city with the lowest cost of living per person, cities with the highest and lowest cost of living per household, cities with the highest household income, cities with the minimum household income, average number of family members per household, as well as the percentage of each independent variable to the cost of living variable.

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Analysis of public transport route medan city using A* algorithm and google maps API for route optimization based on web

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Abstract. *Searching for the optimum public transport route is a problem to find a route between two points with a minimum number of weights. The research method that can be used to solve the optimum route search problem is divided into two stages, namely the first is designing a model device using the A* algorithm and the Google Maps API, the second is designing an Android-based application. The purpose of this research is to develop an android-based system that can contain information on the optimum route for public transportation and information on congestion in the city of Medan.The A* algorithm is a computer algorithm that uses distance estimation by using the closest path search to reach the goal and has a heuristic function that is used as a basis for consideration to determine the choice of a number of alternatives to reach the target effectively. The output of this study is the Android-based application of optimum route information for Medan city public transportation. The level of technology readiness of this research is of the Software type in the validation status of subsystem modules in a laboratory environment with indicators of integrated basic software components working together*.

Keyword : The shortest optimum route, optimum route model, A* Algorithm, Google Maps API

Introduction

The city acts as the center of the activities of its residents diverse so that transportation becomes an important component for sustainability city activity and productivity. The transportation system is very interconnected closely related to the human socio-economic activity system where the transportation system of over time it will develop in line with system developments and changes human socio-economic activity. Changes to the transportation (supply) system must remain able to balance transportation needs.

The city of Medan is currently transforming into a metropolitan city and becoming a center government, trade, education, services and others. Activities in various sectors attracting

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population mobility from the Medan city area itself, and other cities, such as Binjai and Deli Serdang. High population mobility creates a transportation system becomes very important. Public transportation is people's choice, apart from quantity Large fleet, public transport fares are cheaper compared to transportation other general. Apart from that, public transportation has different departure times flexible. Based on data from the dishub.pemkomedan.go.id page, Medan City has 15 public transport companies, namely: PT Rahayu Medan Ceria, KPUM, PTU Morina, CV. Wampu Mini, CV. Transport partner, VC. Advanced village, PT. Mars, PT. Medan National Transport, PT. Povri, CV. Hikma (white), CV. Kobun, CV. Laju Deli Sejahtera, CV. Medan Bus, FA. Mekar Jaya, PU. Gajah Mada, where are each company Public transportation has different numbers of public transportation and different routes different. Calculating the shortest route plays an important role in everyday life – days because it has to be done in a short time and at that time so you can get it quickly Know which route is the most optimal to take

Along with the development of science and technology, a technological development emerged, namely GPS (Global Positioning System). Aiming to find out the location of the place you want to go to and find out where the user is with the help of two satellite signals, GPS itself can provide precise and accurate information regarding position, speed, direction and time (Lukmana, 2014). GPS itself is embedded in sophisticated smartphones with the Android operating system, so that every user can know where the user is without fear of getting lost in an unknown place. Searching for the shortest route is an attempt to find the shortest route from the initial location to the destination location with the fastest travel time compared to other routes. So he was inspired to develop a nearby route search application using a smartphone. This is supported by the development of Smartphone technology and the growth in its use so that this will make it very easy for many people, especially people who are new to living in Medan or who are still unfamiliar with public transportation in Medan City. There are several algorithms that can search for the shortest route. one of them is the A* (A-Star) algorithm. The A* algorithm is an improved algorithm from the Best First Search algorithm which combines Uniform Cost Search and Greedy Best First Search, with modifications to the heuristic function (Pramudhita & Muljono, 2018; Widodo & Ahmad, 2018). The A* algorithm has a heuristic function where the heuristic is an assessor that can provide a price for each node so that it can provide the desired solution (Nuryoso et al, 2020). The A* algorithm is one of the best graph search algorithms that has optimal and complete capabilities in solving problems related to searching or determining routes with the shortest distance (Budiman et al, 2018; Purnama et al, 2018).

According to data from (Statcounter, 2021) Android users in Indonesia are 91.42%, consisting of 8.39% iOS users and 0.04% Windows Operating System users. In the technological era, there are many ways to obtain information based on geographic location with the help of technological devices (Marcelina & Yulianti, 2020). The development of information technology about locations and places makes it easy for everyone to get several locations, one of which is developing graphic data-based information that uses latitude and longitude as location coordinates (Mohamad et al, 2017)

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Research methods

This research carries out a research study on a system run which aims to see the effectiveness in the use of system. And field studies was using Google Maps by searching for sources of information and collecting data from the object to be studied. Data was obtained from the Medan City Transportation Department which consists of two routes, namely the outbound and the inbound route. The data used for the analysis was the number of public transport routes consisting of 10 routes and travel routes for each public transport route in the Medan city.

Figure 1. Shows that the steps for finding optimal public transport routes by inputting the origin and destination points in the form of point coordinates obtained from Google Maps. Next, implement the A* algorithm to find optimal public transportation.

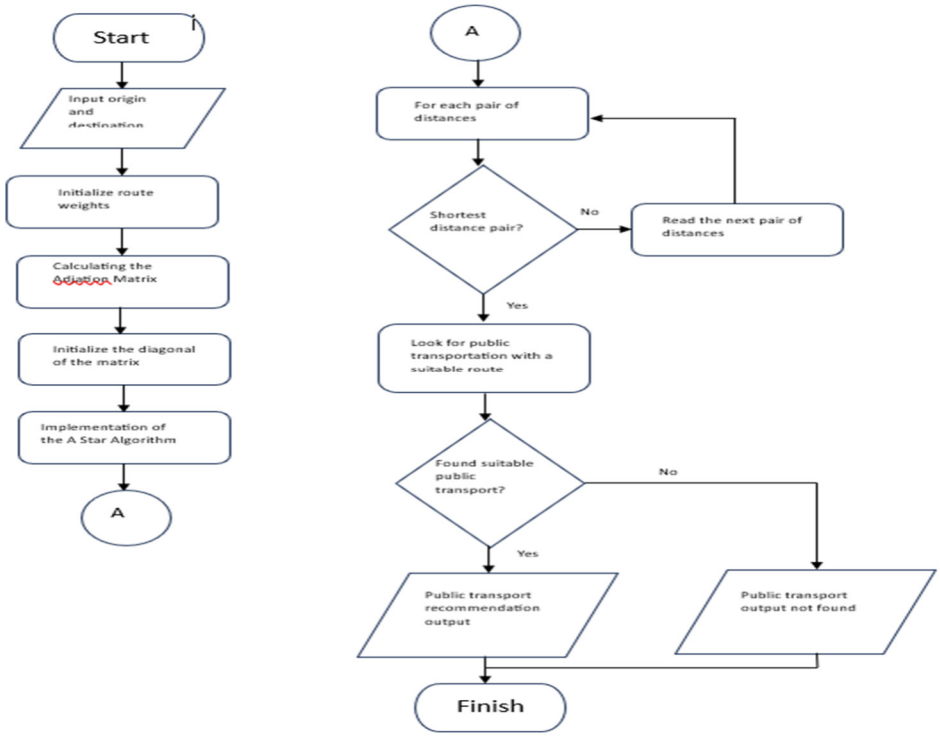

Figure 1. Flowchart determines the optimum public transport route

Data analysis used the A* algorithm with several stages

a. Collecting data in the form of distance data based on grids and points obtained from Google Maps
b. Determining the coordinates of each public transport route and road intersection points determined by taking the longitude and latitude points on Google Maps.
c. Arranging a grid by illustrating all the data obtained, starting from the points and the edges that connect one point to another.
d. Calculating Heuristic values the A* Algorithm
e. Conducting experiments to determine the optimal public transport route

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Figure 2 Figure 2 shows that the implementation of the A* algorithm to find the shortest path from a given starting point to the destination point uses the distance plus cost heuristic function to determine the order in which the search passes through the points on the path.

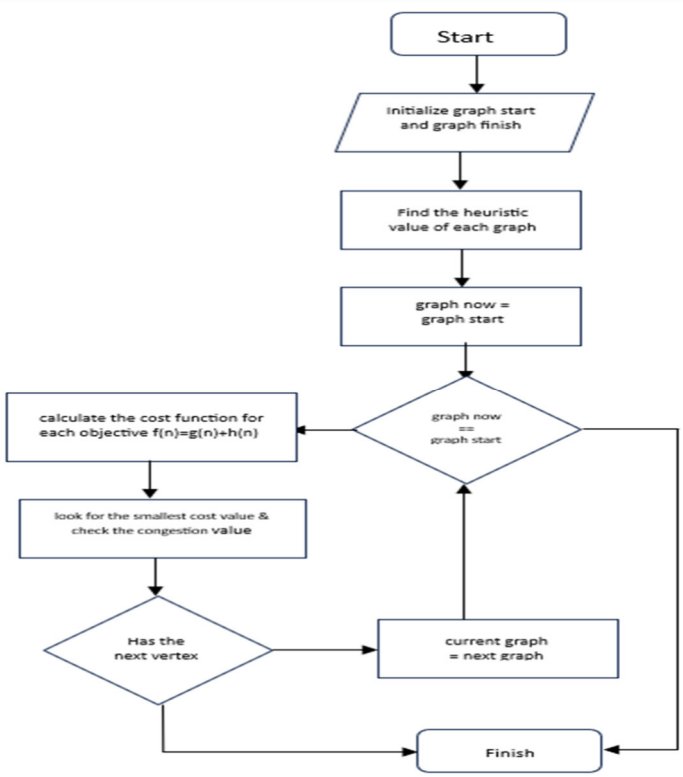

Figure 2. Data analysis flowchart using the A* algorithm

Public transport route data consisting of 10 public transport routes , as shown in figure 3

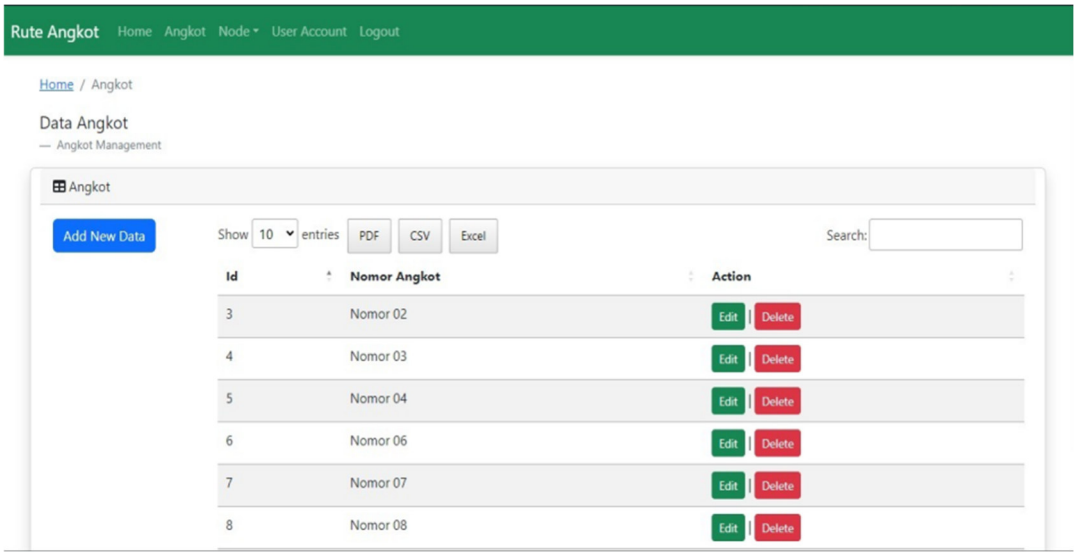

Figure 3. Public transport route data consisting of 10 public transport routes

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Figure 4 shows that the data on the distance of connected road intersection points from public transport routes is obtained from Google Maps

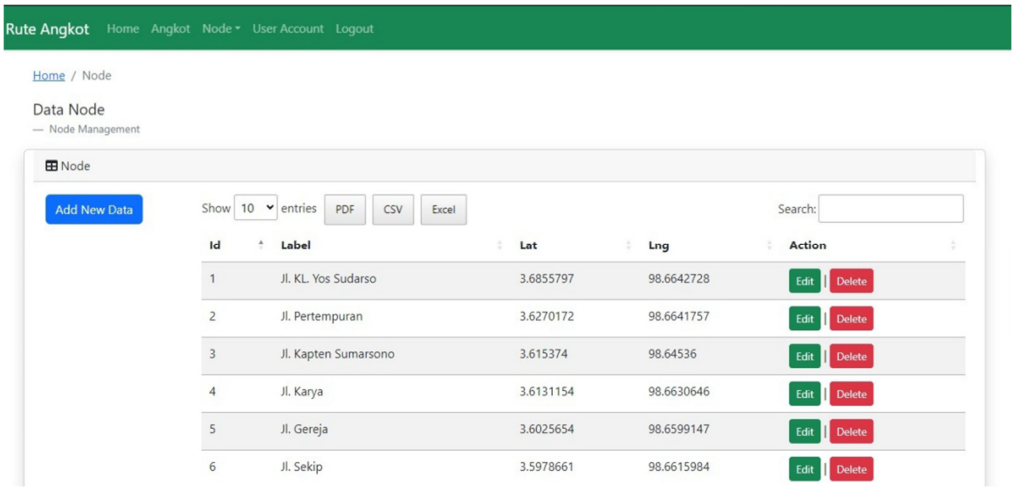

Figure 4. Public transport route distance data

Results and Discussion

The initial stage of finding the shortest route is to transform the road coordinate data of public transport routes into graphic form, as shown in Figure 5.

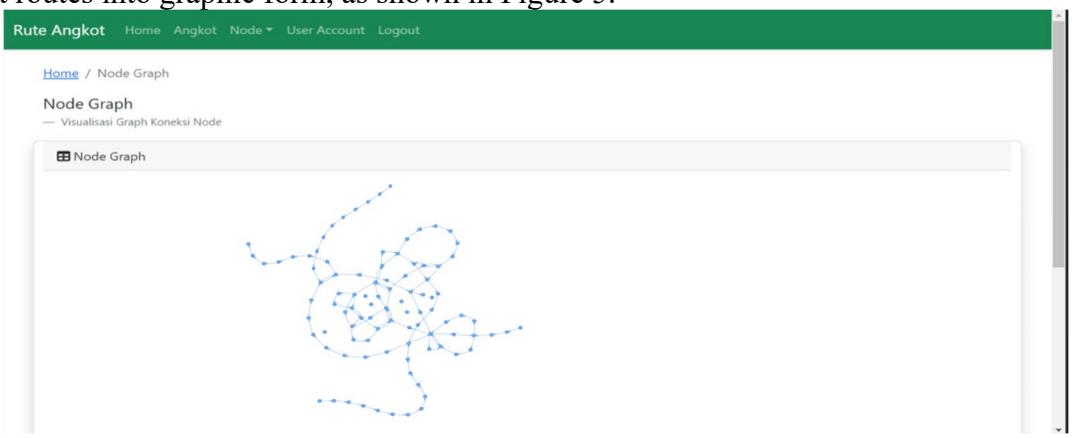

Figure 5. Routes of 10 public transportation in graph form

Figure 5 forms the public transport route for Medan city which consists of 89 points. The dots in this case represent the road coordinates. The points are connected to each other according to road coordinates, data obtained from Google Map of Medan City.

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A* algorithm programming used HTML Web Application, supported by PHP and Javascript programming languages used MySQL and the database as shown below

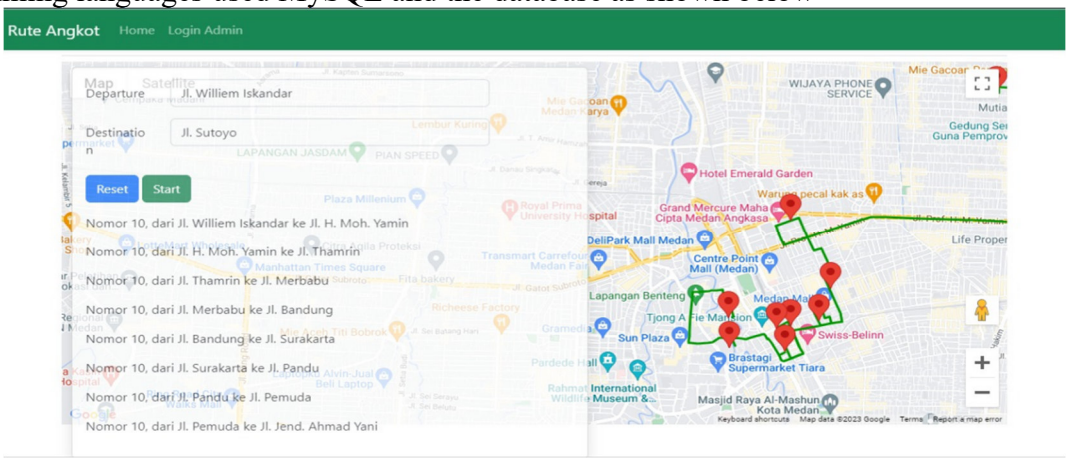

Figure 6. The Web Application Displays looking for the shortest path

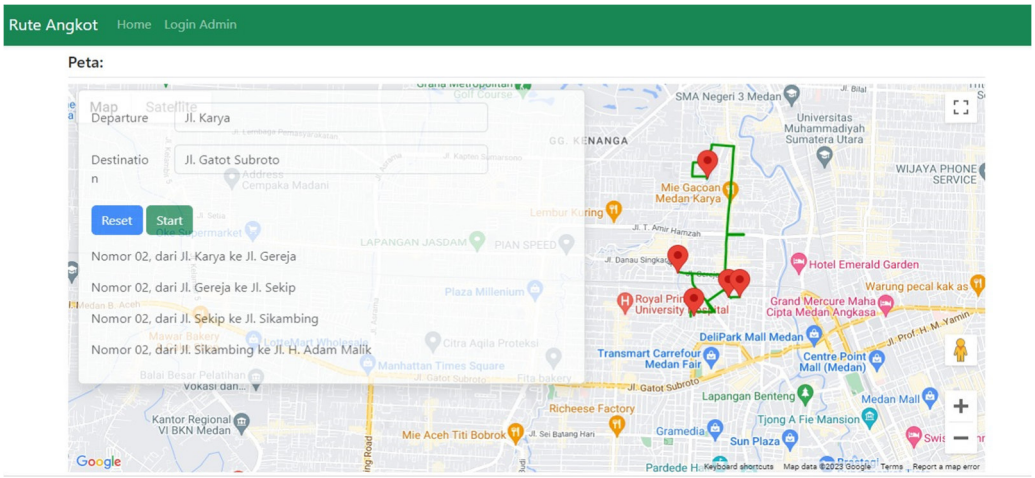

Figure 7. The Web Application Displays looking for the shortest path

The calculation process using the A* algorithm in finding the shortest path between all points in the network was carried out by analyzing the shortest time from the starting point to the destination point so that an estimate of the smallest time solution is obtained using distance and heuristic values.

The A* algorithm is represented as follows (Y. Yuliani, 2016)

$$f(n) = g(n) + h(n)$$

Where:

(n) : Temporary shortest path estimate of n
(n) : Total distance obtained from the starting node to the destination node
$h(n)$: Estimated cost from node n to the destination node

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Conclusion

From the results of this research analysis, the shortest public transport route searched application using the A* algorithm can be used in Medan city. The searching for the shortest public transport route from the initial position to the destination position started from the transformation of road coordinate data obtained from the Google Map API into the form of a public transport route. Then the route formed was made into a neighbour matrix and calculated using the A* algorithm to get the shortest route choice.

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The researcher would like to express a thousand thanks to the entire Unimed LPPM community who have supported this research activity through research grant funds originating from the Medan State University PNBP Fund for Fiscal Year 2023. The researcher also expresses a thousand thanks to the Dean of FMIPA Unimed who has approved this research activity and we would like to express our thousand thanks. also thank the head of the FMIPA Unimed mathematics department for allowing us to carry out this research activity within the mathematics department of FMIPA Unimed. As well as our deepest thanks to all parties who have helped carry out this research activity well.

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Development of Digital Teaching Materials Based on *Higher Order Thinking Skills* (Hots) to Improve Students' Creative Thinking

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Abstract. *This research aims to describe the stages of developing digital teaching materials based on higher order thinking skills (hots) in improving creative thinking abilities and describing the quality of the results of these teaching materials. The quality of development results is determined based on Nieveen's criteria, namely valid, practical and effective. The teaching materials developed are for the "Algebraic Structure" course. The teaching material development model in this research was adapted from the 4-D model development model which consists of the define, design, develop and disseminate stages. The trial was carried out in three stages, namely (1) Trial/expert validation; (2) Limited trials; and (3) Field trials. The field trial was carried out at the Mathematics Education Study Program-FMIPA, Medan State University. The research instruments used were validation sheets, student assessment sheets (responsive questionnaires) regarding the use of Higher Order Thinking Skill (HOTS) based digital teaching materials, creative thinking ability tests. Validity data analysis and practicality data analysis are each carried out by converting quantitative data in the form of assessment scores into qualitative data in the form of standard five scale scores. Data analysis of the effectiveness of students' creative thinking ability tests is determined based on the increase between pre-test scores and post-test scores. This research produced teaching materials consisting of an e-book and 14 handout documents. Each component of the teaching materials for the Algebraic Structure course meets the qualities of being valid, practical and effective.*

Keywords: Development of Digital Teaching Materials, Creative Thinking, HOTS, 4-D Models.

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Introduction

The 21st century is a century of knowledge that combines literacy skills, knowledge abilities, skills, behavior, and mastery of technology which is characterized by creativity and high-level thinking (Miterianifa et al., 2021). That is why the competencies that must be possessed in the 21st century are called 4C which includes creativity and innovation, collaboration, communication, and critical thinking and problem solving. In this century, the emergence of sophisticated information and communication technology in all fields has had an impact on major changes in all aspects of human life, one of which is the educational aspect (Azhary & Ratmanida, 2021). The characteristics of 21st century education are that students must have skills and be able to innovate, master the use of various learning media, and utilize information (Abidin, 2018). This is in accordance with the demands of the Merdeka curriculum, which emphasizes two fundamental aspects of the student profile, namely critical reasoning and creative thinking (Directorate General of Higher Education, Ministry of Education and Culture, 2020).

According to (Lewis & Smith, 1994) higher level thinking will occur if someone has information stored in memory and obtains new information, then connects and organizes and develops that information to achieve a goal or obtain a possible solution to a confusing situation and Higher order thinking skills (HOTS) include critical thinking, creative thinking, problem solving, and decision making.

One effort to develop students' thinking abilities is to master mathematical abilities, such as communication skills, problem solving, reasoning, critical thinking, creative thinking, self-regulated learning and many others. 21st century skills are characterized by critical thinking, creativity, collaboration and communication skills that can be used to solve real-world problems and as important preparation for college and careers (Zakiah et al., 2020). Students are said to be intelligent not only from their ability to answer routine questions accurately and correctly, but also by students who can find various ways or have high creativity so that they are correct in solving the mathematical problems they encounter. Creativity is one of the assets that students must have to achieve their learning achievements.

Creative thinking is something that is very important and must be possessed by students. This is because creative thinking is a mental activity that a person uses to develop new ideas or concepts (Siswono, 2018). Safitri (2019) emphasized that someone who has the ability to think creatively can produce creativity. The ability to think creatively is a thought that is involved in solving a problem using a different approach, so it is very feasible that creative thinking is said to be an important foundation in education to face the challenges of the 21st century. The importance of creative thinking requires educational institutions to be able to instill creative thinking skills in educators, especially when delivering teaching material. One of the teaching materials that makes it possible to instill creative thinking skills is the algebraic structure course, where students are required to have creative ideas in proving existing theorems.

The indicators for mathematical creative thinking abilities according to Torrance (1966) are; a) Fluency, namely having lots of ideas in various categories. b) Flexibility, having diverse ideas. c) Originality, namely having new ideas to solve problems. d) Elaboration, namely being able to develop ideas to solve problems in detail.

Students' creative thinking abilities can be improved through the use of teaching materials, because with interesting and innovative teaching materials, students will be more enthusiastic,

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creative and independent in their learning. Prastowo (2019) explains that there are several purposes for making teaching materials, including: 1) Helping students learn something. 2) Providing various types of teaching material choices to prevent students from feeling bored. 3) Make it easier for students to carry out learning. 4) Learning activities become more interesting.

Widodo (et al., 2018) believes that teaching materials are a set of tools containing learning materials, methods, limitations and ways of evaluating that are designed systematically and interestingly to achieve the expected goals, namely achieving competencies and sub-competencies with all their complexity. . The teaching materials prepared are all forms of materials used to assist teachers or instructors in carrying out teaching and learning activities in class. The teaching materials in question can be written or unwritten materials (Ali Mudlofir, (2017)).

Based on the explanation above, the researcher was moved to design a scientific research, namely developing HOTS-based digital teaching materials to improve the creative thinking abilities of mathematics education students, mathematics department FMIPA UNIMED, especially in the algebraic structure course. The HOTS-based digital teaching materials developed include designing e-books for algebraic structure courses and handouts for each meeting, with the hope that students will be able to learn independently and improve their creative thinking abilities. Based on the main problem formulation, it can be broken down into several problem formulations as follows: (1), What is the validity of HOTS-based digital teaching material development products in algebraic structure courses? (2), What is the practicality of HOTS-based digital teaching material development products in algebraic structure courses? (3), What is the effectiveness of HOTS-based digital teaching material development products in algebraic structure courses?

In general, the objectives of this research are; (1) Describe the validity of HOTS-based digital teaching material development products in the algebraic structure course. (2) Describe the practicality of HOTS-based digital teaching material development products in algebraic structure courses. (3) Describe the effectiveness of HOTS-based digital teaching material development products in algebraic structure courses.

Research Methods

Based on the problem formulation and research objectives set, this research is considered developmental research. This development research is a research method used to produce products and to test the effectiveness of these products (Sugiyono, 2020). The development model for this device uses the Four-D Model suggested by Sivasailam Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel (1974). This development research was carried out to produce HOTS-based digital teaching materials to improve students' creative thinking abilities. The teaching materials produced in this research activity are in the form of e-books (digital books equipped with video motion graphics) and handouts for each meeting.

The development research steps refer to the 4D research design. **First**, the definition stage, namely the stage of establishing and defining learning conditions. At this stage, an analysis of the objectives and limitations of the teaching materials for which the tools will be developed is carried out. This stage consists of five steps, namely: 1) beginning-end analysis, 2) student analysis, 3) task analysis, 4) concept analysis, 5) specification of learning objectives. **Second**, the design stage, namely the stage which aims to produce an initial design of HOTS-based digital

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teaching materials for the algebra structure course which includes: determining learning outcomes for study program graduates and determining course learning outcomes, preparing materials, preparing tests, selecting formats and layout, application in designing learning videos that will be inserted into the ebook. **Third**, the development stage, namely the stage of producing viable HOTS-based digital teaching materials. The teaching materials consisting of ebooks and handouts were tested for validity, practicality and effectiveness. Teaching materials will be revised according to expert input and the results will be tested in the class that is the subject of the research. **Fourth**, the dissemination stage (Dessiminate), this dissemination stage is carried out through international seminar activities organized by FMIPA UNIMED "AISTSSE 2023" and this dissemination stage is also carried out using HOTS-based digital teaching materials which are valid, practical and effective. These digital teaching materials, both ebooks and handouts, are used in Algebraic Structure lectures.

This research was carried out in the mathematics department of FMIPA UNIMED, by using students in the PSPM-E class and PSPM-F class 2020 as research subjects which were carried out in the odd semester of FY 2022-2023. In collecting data for this research, the instruments used were:

1. Product validity instrument. The validation instruments used are (1) ebook validation sheet, (2) handout validation sheet (3) questionnaire validation sheet for lecturers' responses to digital teaching materials (ebooks and handouts) that have been designed, (3) questionnaire validation sheet for student responses to the materials. digital teaching (ebooks and handouts). This validation instrument is used to determine the quality and suitability of the HOTS-based digital teaching materials being developed.
2. Product practicality instrument. To find out the practicality of this HOTS-based teaching material, it is necessary to design a questionnaire sheet on student responses or opinions related to the use of HOTS-based digital teaching materials in learning algebraic structure courses, both responses to the use of ebooks and handouts from algebraic structure courses.
3. Product effectiveness instrument. In this research, 2 assessments will be carried out, namely assessment of creative thinking abilities, assessor (test before implementing HOTS-based digital teaching materials) and posttest scores (test after implementing HOTS digital teaching materials. By calculating the difference between the pretest and posttest scores or the gain score, we will be able to find out whether the use or application of digital teaching materials can be said to be effective or not. In calculating N-Gain the formula is used, namely:

$$\textbf{N-Gain} = \frac{\textbf{Final score- Initial Value}}{\textbf{Maksimum value- Initial Value}}$$

The interpretation criteria for the N-Gain index proposed by Hake (1999) are $g > 0.7$ (high gain index), $0.3 < g < 0.7$ (medium gain index) and $g < 0.3$ (low gain index). Meanwhile, the division of N-Gain acquisition categories in the form of percent (%) can refer to table 1 below:

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Table 1 . Categories Interpretation effectiveness of N-Gain (Hake, R, R. 1999)

Categories Interpretation effectiveness of N-Gain	
Percentage (%)	Interpretation
< 40	Not effective
40 – 55	Less effective
56 – 75	Enough effective
> 76	Effective

Results and Discussion

1. Define Stage Analysis Results

The definition stage aims to define and determine needs in the learning process as well as collecting various information related to HOTS-based digital teaching material products that will be developed and their suitability to learning needs. This stage is divided into several stages, namely; (1) The initial analysis stage is an activity to analyze student needs for learning in the algebraic structure course by distributing questionnaires to students of the mathematics education study program, mathematics department FMIPA UNIMED. The results obtained at this stage, students need digital teaching materials that are interesting, interactive so that they can help them understand the content of the algebraic structures course material. (2) The concept analysis stage is an activity to identify parts of the teaching material that students will study. This analysis is carried out before making teaching materials with the aim of systematically compiling material that will be applied to HOTS-based digital teaching materials, both in ebook and handout form. At this stage the research activities carried out are: a) Preparing material to be presented in HOTS-based digital teaching materials, b) Studying, compiling and summarizing the material, so that when it is presented in HOTS-based digital teaching materials, students can easily understand the concept and the theory provided, c) Consulting the material with the lecturer teaching the algebraic structure course before presenting it in HOTS-based digital materials; (3) Formulating learning objectives, namely determining indicators of learning achievement with the aim of finding out changes in students after the learning process. This change in behavior can be seen from the success of students in understanding the content of the learning material presented by the lecturer.

2. Design Phase Analysis Results

The design stage carried out is planning HOTS-based digital teaching materials that will be developed with the hope of increasing students' creative thinking abilities. The stages carried out are; (1) Selection of learning media. At this stage, the selection of learning media is carried out to identify teaching materials that are relevant to the characteristics of the material and student needs, so that the use of teaching materials is optimal in learning activities for the algebraic structure course; (2) Selection of format, the initial stage that will be carried out for the application of digital teaching materials that have been determined with the aim of ensuring that

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the format chosen is in accordance with the learning material. Selecting the format in development means designing HOTS-based digital teaching materials in the form of ebooks and handouts, designing learning content, determining the main material in accordance with CPMK (Course Learning Outcomes), organizing and designing the content of the ebook and handouts, designing the content of the ebook and handouts, which includes motion graphics video design that will be inserted into the ebook, layout, images and writing; (3) Make initial designs for all learning tools that must be worked on before they are produced, then provide input from colleagues (lecturers who teach algebraic structure courses), input and criticism will be used to improve the initial design of this HOTS-based digital teaching material. For the ebook from the algebraic structure course, it can be seen in Figure 1a and Figure 1b, while the handout is in the form of teaching materials presented using MS. Word as many as 14 documents (one document for one meeting)

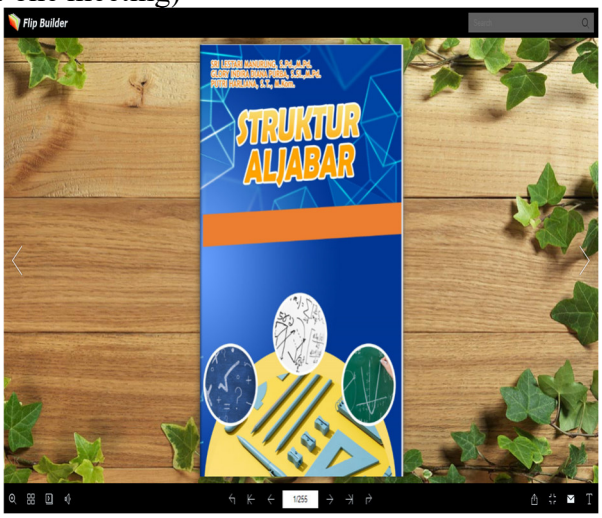

Figure 1a. Appearance front of E-Book

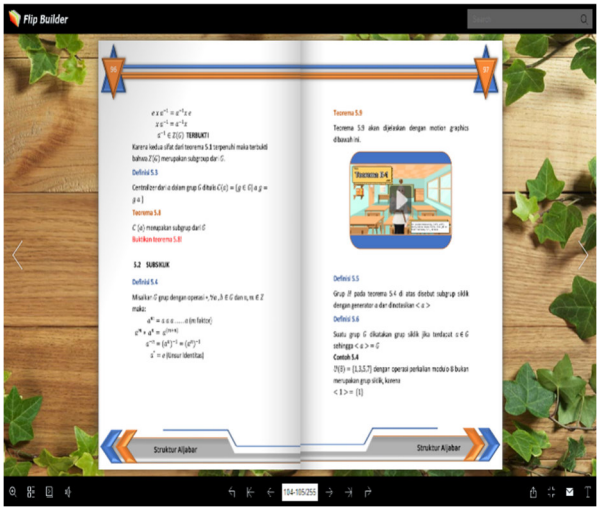

Figure 1b. Appearance contents of the E-Book

3. Development Stage Analysis Results

This development stage is the stage of conducting validation trials, practicality and effectiveness of HOTS-based teaching materials to improve students' creative thinking that has been designed. The test carried out at this stage is to produce HOTS-based teaching materials that are suitable for use in learning activities for algebraic structure courses. The results of this test were obtained based on input from media experts and material experts and a trial was carried out on students to determine the advantages and disadvantages of the teaching materials that had been designed, with the hope that these teaching materials could help students improve their creative thinking abilities in learning algebraic structure courses.

The stages carried out at this development stage include;

1) Validation Test, at this stage a validation assessment is carried out from 2 (two) lecturers as material expert validators and 2 (two) lecturers as media expert validators. Based on the calculations from the validators, it can be concluded that the HOTS-based digital teaching materials developed are valid and can be continued to the testing process stage in small groups, while the comment data in the form of suggestions and criticism from the validators is used to improve the HOTS-based digital teaching materials that have been

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developed. The results of this validation test data can be seen in table 2.

Table 2 . Expert Validation Result Data

No	Validator Name	Mark	Criteria
1	Expert validator media	4.42	Valid
2	Expert validator material	4.58	Valid
	Average	4.5	Valid
	Criteria : Valid		

Next, a trial was carried out on a small group. This small group test was carried out on 20 students who had taken the algebraic structure course, as a test of the readability of the teaching materials developed, namely for the response to the teaching materials of the 20 students, 17 students gave positive responses and 3 students gave moderate responses (see table 3).

Table 3. Criteria Response Student To Structure E-book Products Algebra

STUDENT RESPONSE CRITERIA	THE NUMBER OF STUDENTS	PERCENTAGE
POSITIVE	17	85%
CURRENTLY	3	15%
NEGATIVE	0	0%

Table 4. Data from E-book Readability Test Results structure algebra

Average score	Percentage	Criteria
33.76	85%	Good

Based on Table 4, it provides an illustration that the algebraic structure teaching materials have good readability scores or in other words it can be concluded that this e-book is easy to understand.

2) Practicality Test

This practicality test stage was carried out in the research class after using HOTS-based digital teaching materials in the PSPM-E and PSPM-F 2020 classes in the algebraic structure course, with a total of 73 students. Data from this large group is to see the practicality and effectiveness of the teaching materials developed, namely e-books and algebra structure handouts. This trial in a large class was carried out by distributing student response questionnaires with the results of the practicality test of HOTS-based digital teaching materials products which can be seen in table 5 and table 6.

Table 5. Criteria Response Student To E-book products

STUDENT RESPONSE CRITERIA	NUMBER OF STUDENTS	PERCENTAGE
POSITIVE	64	87.67%
CURRENTLY	9	12.33%
NEGATIVE	0	0%

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Table 6. Data from Readability Test Results for Set and Logic E-books

Average score	Percentage	Criteria
34.53	87.67	Good

Based on table 6, it can be seen that the practicality test value is at 87.67% with good criteria. Therefore, it can be concluded that HOTS-based digital teaching material products in the algebraic structure course are declared practical to use.

3) Effectiveness Test

This analysis aims to determine the effectiveness of this digital teaching material product in the algebraic structure course. The results of testing the effectiveness of this digital teaching material were carried out by calculating the N-Gain value based on students' creative thinking tests. The results of this student creative thinking test are calculated from the pretest and posttest scores (see table 7).

Table 7 . Upgrade Data Ability Think Creative Student

Average	Pre-test	Post-test	Gains
Aspect Evaluation	52.81	87.55	0.75 _

Based on table 7, you can see an increase in the average score of students' creative thinking abilities from pretest to posttest. Based on the gain index, the increase that occurred was 0.75, which was categorized as a high or significant increase.

4) Dessiminate Stage Analysis Results

At this stage, we are disseminating research results at the international seminar "The 10th Annual International Seminar On Trends In Science And Science Education (AISTSSE) 20231". This scientific paper will be published in the Journal of Physics: Conference Series (JPCS) indexed by Scopus. Apart from that, the dissemination stage was also carried out in learning activities for the algebraic structure course using HOTS-based digital teaching materials.

Conclusion

Based on the results of the research and data analysis that has been carried out, the conclusion of this research is that the development of HOTS-based teaching materials using the 4-D development model (Define, Design, Development, Desiminate) can improve students' creative thinking abilities in learning algebraic structure courses based on the calculated N-Gain value is 0.75 (effective category).

This HOTS-based digital teaching material is suitable for use based on the results of the validation analysis test, namely 4.5 (valid category) and this HOTS-based digital teaching material is also practical for use in learning algebraic structure courses, namely with a practicality value of 87.67%.

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Acknowledgments

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Decision Support System (DSS) for assessment of tracer study results to improve the quality of graduates

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Abstract. *A tracer study is a method to track and get feedback from the alumni of an educational institution, particularly higher education institutions. The results of this tracer study are generally used by universities to improve the quality of their education system. In addition, the feedback from the tracer study is also very useful for universities in gaining an overview of the business and industrial world. Besides for accreditation purposes, tracer studies also aim to know the educational outcomes and evaluate the learning process in universities in order to improve the quality of graduates. The problem that occurs is that the tracer study conducted by universities so far is only to meet the needs of administrative accreditation. Tracer studies are only conducted when a study program is going to be accredited. The thing done is just to distribute questionnaires in the form of a google form to be filled out by respondents. After the accreditation process is completed, the results of the tracer study are also wasted and no longer useful. Whereas the results of the tracer study contain value that can be used as a picture or benchmark for the study program to see what the quality of the graduates that have been produced by the study program. In addition, the results of the tracer study can also be used as a reference to evaluate and improve the teaching and learning process in order to improve the quality of graduates. This research is related to the evaluation of the results of the tracer study. The output of this research is the availability of a database of tracer study results that have been done. This data can be accessed at any time and can be added to or updated with tracer study data in the following years, so that the data from the tracer study results obtained are not wasted. In addition, the data from the tracer study results can also be processed and assessed using a Decision Support System (DSS). The results of this data processing can be used as a reference to improve the quality of graduates.*

Keywords: decision support system, tracer study, quality of graduates

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Introduction

The quality of college graduates is an important concern for the government, educational institutions and society, both locally and nationally. To find out the quality of graduates from a university is usually done by means of a tracer study. Tracer study is a method for tracking and getting feedback from alumni of an educational institution, especially universities. The use of tracer studies is a mediation in measuring graduate performance [1]. The results of this tracer study are generally used by universities to improve the quality of their education system. The quality of a higher education institution must always be evaluated to obtain accreditation from the government [2]. Apart from that, the results of feedback from tracer studies are also very useful for universities in obtaining an overview of the world of business and industry. In this way, universities can find out the competencies their alumni have with the skills needed in the labor market.

Achieving the quality of graduates is not only based on a good academic achievement index, but also the right study period, suitability for graduate employment and graduate competency that is able to compete in the world of work [3]. Based on Minister of Education and Culture Regulation no. 49 of 2014 concerning national standards for higher education which states that achieving good quality graduates is influenced by the level of graduation on time and suitability of the field of knowledge to the job. Tracer study activities are part of the evaluation process to see the success achievements of graduates in terms of the suitability of graduate competencies by graduate users. Furthermore, tracer study is an effort to find information to determine policies, planning and decision making related to the vision and mission, curriculum, learning process and user satisfaction with the quality of graduates.

The problem that occurs is that the tracer studies carried out by universities so far are only to fulfill administrative accreditation needs. Tracer studies are only carried out when the study program is to be accredited. What is done to obtain information from alumni is by distributing questionnaires in the form of google forms for respondents to fill in. After the accreditation process is complete, the tracer study results are no longer useful. In fact, the results of the tracer study contain values that can be used as an illustration or benchmark for the study program to see what quality the graduates produced by the study program are like. Apart from that, the results of the tracer study can also be used as a reference for evaluating and improving the teaching and learning process in order to improve the quality of graduates.

The research related to the assessment of tracer study results is very important to carry out because the output of this research is the availability of a database of tracer study results that has been established. This data can be accessed at any time and can be added or updated with tracer study data in subsequent years, so that the tracer study data that has been obtained is not wasted. Apart from that, the data from the tracer study can also be processed and assessed using the Decision Support System (DSS). The results of data processing can be used as a reference to improve the quality of graduates.

This research will apply the Simple Additive Weighting (SAW) method to determine a suitable graduate profile for students. The SAW method is one of the simplest and most widely used Multi Attribute Decision Making (MADM) problem solving methods [4]. The SAW method is a method in a basic concept that can make a decision on the total weight of each alternative on all attributes [5], [6].

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Research Method

The stages in this research as shown in Figure 1.

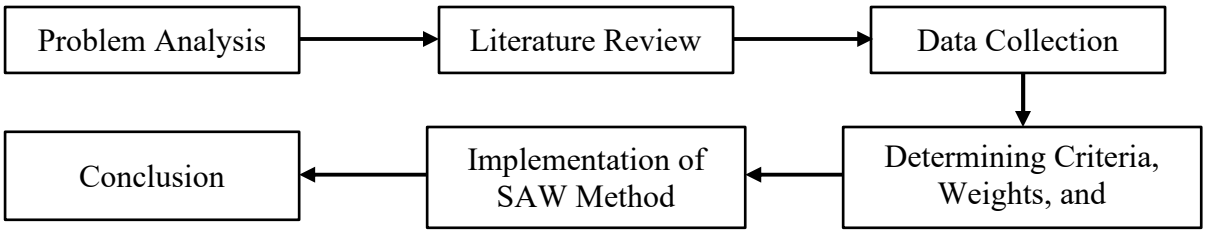

Figure 1. Research Stages

Problem Analysis

Problem analysis phase is for identify the object of research and the related environment in order to explore the situation and conditions of the problems that happened. Problem analysis was conducted to collect information about the process of tracer study. In addition, How the results of this tracer study are used by universities to improve the quality of their education system.

Literature Review

Literature review is a technique of integrating findings and perspectives from many empirical findings where this technique can answer research questions with strengths that no single study has [7]. In general, literature reviews summarize and evaluate a collection of writings on a particular topic [8]. Based on this, the literature review in this study is a written summary of the results of the study of journals, books, and other documents in accordance with the needs of developing a tracer study system.

Data Collection

The next stage of this research is to collect data related to the Tracer Study of alumni of the Computer Science study program, Faculty of Mathematics and Natural Sciences, Medan State University. The data collected is graduate GPA data, length of study period, waiting time for graduates to be accepted for work, job suitability with graduate competencies, graduate user satisfaction, and other necessary data.

Determining Criteria, Weights, and Alternatives

Determination of criteria, weights and alternatives refers to the results of the tracer study. The criteria in this research are the graduate's GPA, length of study period, waiting time for graduates to be accepted for work, job suitability with graduate competencies, graduate user satisfaction, and the alternative is alumni who have filled out the tracer study form. Meanwhile, determining the weight of each criterion varies for each criterion based on the level of importance of each criterion.

Implementation of SAW Method

Decision Support System (DSS) is a computer-based system designed to increase effectiveness in decision making that can solve semi-structured and unstructured problems, so that the decision-making process can be of higher quality [9]. DSS will be effective if it has five

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characteristics, namely, performance, ease of use, trustworthiness, cost, and conformity to existing habits or relevance [10]. One method that can be used in DSS is Simple Additive Weighting (SAW). Simple Additive Weighting (SAW) is a method in a basic concept that can make a decision on the total weight of each alternative on all attributes [11], [12]. The SAW method requires a process of normalizing the decision matrix x to a scale that can be compared with existing alternative ratings [13]. The formula for the SAW method is as follows [9]:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{Max\ x_{ij}} & If\ j\ is\ the\ benefit\ attribute \\ \frac{Min\ x_{ij}}{x_{ij}} & If\ j\ is\ the\ cost\ attribute \end{cases} \quad (1)$$

r_{ij} = normalized performance branch value
x_{ij} = attribute value that is owned from criterion
$Max\ x_{ij}$ = the highest value of each criteria
$Min\ x_{ij}$ = the lowest value of each criteria

Meanwhile, the level of preference for each alternative (Vi) is as follows:

$$V_i = \sum_{j=1}^{n} W_{ij} r_{ij} \quad (2)$$

V_i = end value alternative
W_{ij} = weight predetermined
r_{ij} = normalization matrix

There are several stages of SAW in this research, namely as follows [9], [10]:

1. Determine the criteria that will be used as a reference in decision making, namely Ci
2. Determine the weight of each criterion
3. Determine the alternative whose tracer study results will be assessed
4. Rate each alternative on each criterion. Then Normalize the matrix based on the type of attribute, so that a normal matrix is obtained
5. Calculate value of the normalized matrix values for each alternative
6. Do ranking. The final result obtained from the ranking process is that the largest value is selected as the best alternative (Ai).

Conclusion

Conclusion is the final stage in this research. Based on the Big Indonesian Dictionary, a conclusion is a decision obtained based on a deductive or inductive way of thinking from a particular discussion or idea. After obtaining the final results at the implementation stage, at this stage the final conclusion is obtained regarding the tracer study.

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Result and Analysis

There are several steps to calculate the tracer study using the Simple Additive Weighting (SAW) method, including:

1. Criteria and Weights
   Criteria is tracer study result obtained from the Computer Science Study Program. The Criteria in this study shown in Table 1.

Table 1. Criteria and Weights of each criterion

Criteria	Information	Weights	Attribute
C1	Graduate GPA	20%	Benefit
C2	Length of study period	15%	Cost
C3	Waiting time for graduates to be accepted for work	25%	Cost
C4	Job suitability with graduate competencies	10%	Benefit
C5	Graduate user satisfaction	30%	Benefit

2. Weights of each Criteria
   The next step is to assign a weight to each criterion. The weight of each criterion is as follows:

Table 2. Weights of Graduate GPA

Scale	Weights
< 2.50	1
2.50 – 2.99	2
3.00 – 3.49	3
3.50 – 4.00	4

Table 3. Weights of Length of study period

Scale	Weights
≤ 4 years	1
> 4 – 5 years	2
> 5 – 6 years	3
> 6 years	4

Table 4. Weights of Waiting time for graduates to be accepted for work

Scale	Weights
≤ 3 months	1
> 3 – 6 months	2
> 6 – 12 months	3
> 12 months	4

Table 5. Weights of Job suitability with graduate competencies

Criteria	Weights
not suitable	1
less suitable	2
suitable	3
very suitable	4

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Table 6. Weights of Graduate user satisfaction

Criteria	Weights
not satisfied	1
less satisfied	2
satisfied	3
very satisfied	4

3. Value of each Alternative on each criterion
   The value of each alternative can be seen in table 7.

Table 7. The value of each alternative for each criterion

Alter-native	Graduate GPA	Length of study period (year)	Waiting time for graduates to be accepted for work (moon)	Job suitability with graduate competencies	Graduate user satisfaction
A1	3.30	4.6	4	less suitable	satisfied
A2	3.70	3.8	7	suitable	less satisfied
A3	2.85	5.6	3	very suitable	satisfied
A4	3.25	4.5	8	not suitable	not satisfied
A5	2.40	6.3	1	less suitable	very satisfied

4. Value of the weight of each alternative for each criterion
   The next step is to determine the weight value of each alternative for each criterion. The weight of each alternative for each criterion used in tracer study can be seen in Table 8.

Table 8. The value of the weight of each alternative for each criterion

Alter-native	Graduate GPA	Length of study period	Waiting time for graduates to be accepted for work	Job suitability with graduate competencies	Graduate user satisfaction
A1	3	2	2	2	3
A2	4	1	3	3	2
A3	2	3	1	4	3
A4	3	2	3	1	1
A5	1	4	1	2	4

The next step is to normalize the weight value of each alternative for each criterion. The formula for normalizing the weight value can be seen in Equation 1.

The results of normalizing the weight value of each alternative for each criterion can be seen in Table 9.

Table 9. The results of normalizing the weight value of each alternative for each criterion

Alter-native	Graduate GPA	Length of study period	Waiting time for graduates to be accepted for work	Job suitability with graduate competencies	Graduate user satisfaction
A1	0.75	2	2	0.5	0.75
A2	1	4	1.33	0.75	0.5
A3	0.5	1.33	4	1	0.75
A4	0.75	2	1.33	0.25	0.25
A5	0.25	1	4	0.5	1

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5. Calculate value of the normalized matrix values for each alternative
   The next step is to calculate the value of each alternative by multiplying each normalized data by the weight of each criterion. The formula for Value Calculation of each alternative can be seen in Equation 2.

   The results of normalizing the weight value of each alternative for each criterion can be seen in Table 10.

Table 10. The value of Calculation each alternative

Alter-native	Graduate GPA	Length of study period	Waiting time for graduates to be accepted for work	Job suitability with graduate competencies	Graduate user satisfaction
A1	0.15	0.30	0.50	0.05	0.23
A2	0.20	0.60	0.33	0.08	0.15
A3	0.10	0.20	1.00	0.10	0.23
A4	0.15	0.30	0.33	0.03	0.08
A5	0.05	0.15	1.00	0.05	0.30

6. Calculation of Final Value (Preference Value)
   The last step is to calculate the final result or preference value obtained from the sum of the results of multiplying the normalization of alternative scores and the normalization of the alternative weight values for each criterion. Calculation of the final results shown in Table 11.

Table 11. Final Calculation Results

Alter-native	Amount	Rank
A1	1.225	4
A2	1.358	3
A3	1.625	1
A4	0.883	5
A5	1.550	2

Based on the calculation results and ranking results in Table 10, The highest value is Alternative 3 (A3) with Total Value = 1.625.

Conclusion

Based on the results of the calculations that have been carried out for each alternative, it can be concluded that the highest value is alternative 3 (A3), with a value of 1.625. It can be concluded that Alternative 3 (A3) has the best tracer study value of all. And the lowest value is alternative 4 (A4), with a value of 0.883.

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Development Of Higher Education Tridharma Recapitulation Information System For Lecturers Of Computer Science Department Universitas Negeri Medan

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Abstract. *Lecturer is a profession that required to fulfill lot administrative requirements as a condition for increase promotion and rank. Most of the documents requested for administrative requirements are documents of tridharma activities. The smooth running of the administration is very dependent on how well the lecturers keep all these documents. The fact that happened is that there are so many lecturers not too serious about keeping documents of their tridharma activities, causing these documents to be difficult to get back. This can be proven by the fact that there are still many lecturers who are very difficult to manage administration in matters of promotion and rank. This tridharma recapitulation information system is an idea to solve the problems that have been mentioned. In this application, it is possible for lecturers to store information and documents of their tridharma from anywhere and anytime as log as they are online. In the end, when the time came to take care of administrative documents for promotion and rank, the lecturer only needed to access the website, which summoned all the data and information needed.*

Keywords: tridharma activities, information system, website, Software Development Life Cycle (SDLC)

Background

The Tri Dharma of Higher Education is a set of three core pillars that constitute a fundamental component in achieving the vision and mission of every institution of higher learning. The Tri Dharma of Higher Education consists of Education and Teaching, Research, and Community Service. Each lecturer in a higher education institution is obligated to fulfill the duties associated with the Tri Dharma of Higher Education [3]. In addition to these three components, there are also additional elements crucial to supporting a lecturer's career, such as engaging in scholarly activities, participating in specific committees, or holding temporary positions.

Lecturers are professional workers who are required to carry out the three core duties of

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higher education, which are included in the workload of lecturers. According to Government Regulation No. 4 of 2014 in Indonesia, universities have autonomy to independently manage their institutions as centers for the implementation of the Tri Dharma of Higher Education[4].

The issue faced by Computer Science lecturers at Unimed is the difficulty in efficiently and effectively managing the storage of Tri Dharma data and other supporting data. Consequently, every administrative task, such as lecturers' workload (BKD), applications for promotions and rank advancements, and the completion of employee performance target forms (SKP), tends to pose ongoing challenges. This often leads to delays and, in some cases, results in lecturers being unable to achieve promotions for years. Another issue experienced by lecturers is the multitude of applications that must be filled out. However, these applications cannot be reused when needed because the data entered can be deleted at any time due to policy changes and system errors. Furthermore, storing data on laptops or smartphones does not guarantee the safety of the data, as it can be lost or compromised due to device malfunction or damage.

The higher education tridharma recapitulation information system is a platform that can be utilized as a repository for storing higher education tridharma data, and it facilitates lecturers in retrieving this data based on the semester or year. This system will also be designed to be integrated, meaning that data owned by lecturers with interrelationships will automatically be added to those lecturers, so the same data only needs to be input once.

Literature

Tri Dharma

Based on the Republic of Indonesia Law No. 12 of 2012 concerning Higher Education, it is stated that the three pillars of higher education, often referred to as "Tri Dharma," are the responsibilities of higher education institutions to provide education, conduct research, and engage in community service.

The scope, depth, and combination of implementing the Tri Dharma are carried out in accordance with the characteristics and needs of each type and program of Higher Education. The entire role of higher education institutions in delivering education to students and the community, educating future national leaders, advancing knowledge and technology, fostering the study of ethics and moral strength to seek and discover the truth, and promoting the development of the nation's civilization is all achieved through the activities of the Tri Dharma as defined in the Statute of the Higher Education Institution.

Lecturer

According to Regulation of the Republic of Indonesia No. 37 of 2009 on Lecturers, a lecturer is a professional educator and scientist with the primary task of transforming, developing, and disseminating knowledge, technology, and the arts through education, research, and community service.

Lecturers are required to have academic qualifications, competencies, teaching certificates, physical and mental health, and meet other qualifications required by the higher education institution where they work. They must also have the ability to realize the goals of national education. Lecturers hold a professional position in the higher education sector and are appointed in accordance with the prevailing laws and regulations.

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Lecturer Workload

A lecturer's workload encompasses core activities, which include planning for instruction, delivering the teaching process, assessing learning, providing guidance and training, conducting research, handling additional tasks, and engaging in community service.

Research Methods

The research method used is the Software Development Life Cycle (SDLC). In the planning phase, activities involve collecting information and data according to the needs of lecturers for comprehensive recording of the Tri Dharma, which will be analyzed to define the requirements of the program. The analysis phase is carried out to identify software needs and determine the types of data to be used, as well as to analyze the strengths and weaknesses of previously used applications. During this stage, activities include designing software in the form of mockups and Unified Modeling Language (UML) diagrams, as well as designing the database using Entity Relationship Diagram (ERD).

In the implementation phase, the activities involve translating the designs from the previous stage into program codes that have input-process-output in accordance with the design. At this stage, application testing is performed in a limited area and with a limited number of users to determine whether the entire system functions as expected and planned. In this phase, the activities include publishing and promoting the application to the general public, while still periodically checking and evaluating any issues or shortcomings in the application.

Firgure 1. SDLC (Software Development Life Cycle) diagram

Application Context Diagram

An overview of the application is created based on entity information and input/output of the application using a context diagram, as follows:

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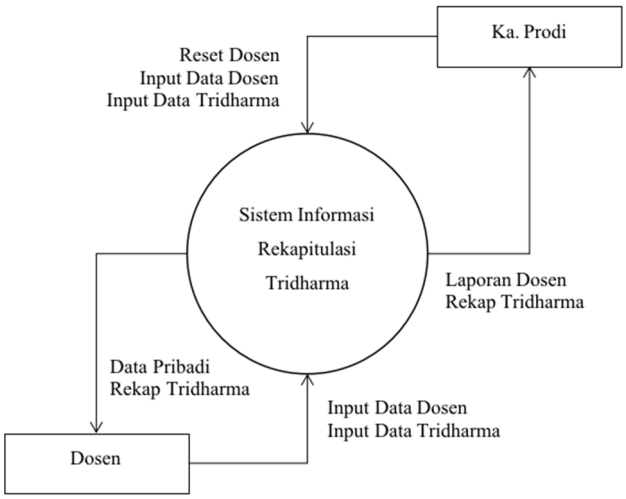

Firgure 2. Application Context Diagram

Based on the above context diagram, it can be concluded that the information system for summarizing the Tri Dharma can be accessed by lecturers and program study heads who also have access as lecturers. The program study head can enter lecturer and Tri Dharma data, and can reset the passwords for lecturers in the same program of study. The program study can view lecturer data and the summary of Tri Dharma data for lecturers in the same program of study. Lecturers can enter personal data and can view Tri Dharma data, as well as access a summary of all data that can be filtered by year.

List of Database Tables

There are 23 tables that have been designed to run the application for the higher education Tri Dharma summary information system for the Computer Science program at the Faculty of Mathematics and Natural Sciences, Unimed. The following tables can be seen below:

Table 1. List of database table used in application

Tables Name					
user	dosen	skema_penelitian	team_teaching	jenis_luaran	sumber_dana
fakultas	mahasiswa	pengabdian	sk_mengajar	penunjang	file_pribadi
jurusan	penelitian	skema_pengabdian	luaran	anggota_penunjang	jenis_keanggotaan
prodi	anggota	pengajaran	anggota_luaran	akreditasi	

Application Design

The images below are some important parts of the application design that can be presented. The displayed application design includes the research page, the community service page, and the summary page design.

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(a) (b) (c)

Figure 3. research design page (a) Community service design page (b) Recapitulation design page (c)

Application Implementation

This recapitulation application was developed using PHP programming language, web-based, and runs on an Apache server, utilizing a MySQL database. Below are some screenshots from the application that has been running using a researcher's account.

(a) (b) (c)

Figure 4. Research page (a) Community service page (b) Recapitulation page (c)

Conclusion

Designing a database that can accommodate the tri-dharma data of Computer Science program lecturers at Unimed involves identifying all types of tri-dharma data and conducting an analysis.

The method for designing and constructing the higher education lecturer's Tri Dharma recapitulation information system for the Computer Science program at Unimed is by developing a web-based application capable of storing Tri Dharma data. This includes creating access pages for lecturers and program study heads, and, in essence, building features for summarizing higher education Tri Dharma data that can be filtered according to the needs of lecturers and program study.

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Comparison of Convolutional Neural Network Architecture for Identification of Hypertensive Retinopathy Using Retina Fundus Images

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Abstract. Convolutional Networks is one of the Deep Learning methods that has been consistently developed for the detection, classification, and segmentation of an object. CNN has several models whose function is to classify and detect images accurately which continue to grow every year, especially in the medical world. One of the diagnoses that can be identified by CNN architecture through fundus images is Hypertensive Retinopathy (HR). HR is a disorder of the retina caused by abnormal blood pressure that can cause blindness if not detected early, but HR can only be detected using a fundoscope. Therefore, this research will provide a solution to detect HR using several CNN architectures through fundus images. This research will also look at which CNN architecture produces a more precise and clear diagnosis. Classification of Hypertensive Retinopathy (HR) uses several CNN algorithms through fundus images. Several architectural models in this study are AlexNet, DenseNet, Inception-V3, InceptionResNetV2, Lenet-5, MobileNetV2, ResNet50, VGG16, and VGG19. The stages of this research were collecting data from STARE, dividing the dataset, namely 80% training data and 20% testing data, preprocessing stages by removing the background fundus

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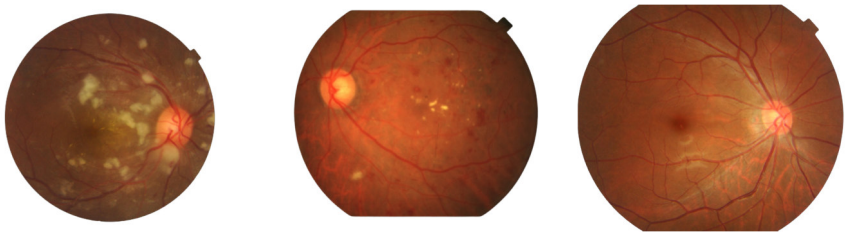
image, implementing CNN, and the last stage was evaluating the CNN model using the confusion matrix. The results of this study indicate that of the nine CNN architectures tested, the VGG19 architecture obtained the highest accuracy and F1 score where the accuracy value was 0.92 and the F1 score was 0.93.

Keywords: CNN, deep learning, classification, hypertensive retinopathy, images.

Background

Convolutional Networks is one of the Deep Learning methods that has been consistently developed for the detection, classification, and segmentation of an object. The use of Convolutional Neural Networks (CNN) in image detection has greatly assisted the medical world in studying data representation [1]. CNN has several architectures such as AlexNet, GoogleNet, Inception V3, Residual Network (ResNet) 50, and ResNet 18 [2]. Each architectural model has its own algorithm and precision. One model, namely AlexNet, is the first model to apply Deep Learning to image classification and makes it a breakthrough in CNN neural networks where the proportion of parameters is good so that AlexNet produces good results [3]. Meanwhile, ResNet is a CNN model that has made a series of breakthroughs in the field of image recognition and classification to solve more complex tasks and to improve classification or recognition accuracy which has become a trend [4]. Based on this, CNN has several models whose function is to classify and detect images accurately which continue to develop every year, especially in the medical world.

One of the diagnoses that can be identified by CNN architecture through fundus images is Hypertensive Retinopathy (HR). HR is a disorder of the retina caused by abnormal blood pressure which, if not analyzed at an early stage, will result in blindness [5]. Abnormal and uncontrolled blood pressure can damage the retinal microcirculation resulting in the appearance of cotton wool spots (Cotton Woll Spots/CWS) on the retina [6]. HR cannot be diagnosed with the naked eye by a general practitioner, HR can only be seen using a funduscopic device owned by an ophthalmologist [7], [8]. However, it is important for general practitioners to be able to detect early symptoms for patients with HR to avoid blindness. Figures 1 will provide an overview of the normal retina and retina affected by hypertension.



(a) (b) (c)

Figure 1. Retinal image (a) Hypertensive Retinopathy (b) Diabetic Retinopathy (c) Normal

Figure 1 shows clearly the difference in retinal appearance in normal patients with patients with hypertension and diabetes. A retina that has been affected by hypertension has Cutton Woll Spots that partially cover the layers of the retina. This is what will cause blindness if not diagnosed at an early stage. HR has four levels in its classification, namely at the initial stage or

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the first stage, namely the occurrence of arterial abnormalities in the retina caused by genetic disorders; the second stage is the narrowing of blood vessels in the retina; the third stage is the appearance of white spots on the retina layer, and the final stage is the occurrence of bleeding in the pupils resulting in blindness [6]. Therefore, this research will provide a solution to detect HR using several CNN architectures through fundus images. This research will also look at which CNN architecture produces a more precise and clear diagnosis.

Research Methods

Classification of Hypertensive Retinopathy (HR) uses several CNN algorithm architectures through fundus images. Several architectural models in this study are AlexNet, DenseNet, Inception-V3, InceptionResNetV2, Lenet-5, MobileNetV2, ResNet50, VGG16, and VGG19. The research procedure begins with data collection and then enters the stage of separating the data into training data and test data. Both training data and test data will enter the preprocessing stage to improve image quality. However, in the next stage, the training data that has passed the pre-processing stage enters the CNN design and CNN classification stages, and the final stage is model testing.

Collecting Data

The data in this study are retinal fundus images obtained from several sites that provide data regarding retinal analysis or can be called Structured Analysis of the Retina (STARE). The appearance of a normal fundus retinal image looks transparent and the retinal arterioles and venules run on the nerve fibers lining the retina which are easily visible on fundoscopy [9]. Retinal image data collection was obtained from several sources which can be seen in Table 1.

Table 1. *Retina Fundus Image Dataset*

Class	Sum	Source
Hypertensive Retinopathy (HR)	58	https://cecas.clemson.edu/~ahoover/stare/ https://paperswithcode.com/dataset/dr-hagis https://www.kaggle.com/datasets/linchundan/fundusimage1000
Diabetic Retinopathy (DR)	69	https://cecas.clemson.edu/~ahoover/stare/
Normal	78	https://cecas.clemson.edu/~ahoover/stare/ https://www.kaggle.com/datasets/linchundan/fundusimage1000

Data Sharing

The second stage is the division of the fundus image dataset into two parts, namely training data and test data. At this stage, the training data is classified into the form of the CNN model, while the test data is used to test the accuracy of the classification of the model that has been formed. The two data have a dataset division, namely 80% training data and 20% testing data [10].

Data Preprocessing

At the preprocessing stage, the data only carried out the image filtering stage, namely removing the background on the normal retinal fundus image and HR. These steps are carried out to

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remove the dim light intensity in the image [11]. The process of removing the background is also carried out to remove some unwanted features [12] this is to remove the noise contained in the image. After the data pre-processing stage, the CNN implementation stage is then carried out on normal retinal fundus images and HR which have been removed from the background.

Implementation of CNN

Convolution Neural Networks (CNN) are part of the Deep Learning architecture which is currently the choice in detecting and classifying images [13], analyzing and interpreting medical imaging [14]. CNN can learn the hierarchy of features used for high image classification purposes and the CNN architecture has multilayers specifically designed for real retinal data [15]. In the CNN process, the fundus image is inserted into the residual tissue after the preprocessing stage then enters the image characterization stage obtained from the last network layer pooling, plus several metadata variables, then sent to a decision maker to distinguish healthy fundus images from HR fundus images [16]. CNN has many architectural models, this study will differentiate the results of the 9 CNN models where the process of detecting retinal fundus images adopted from [17] can be seen in Figure 2.

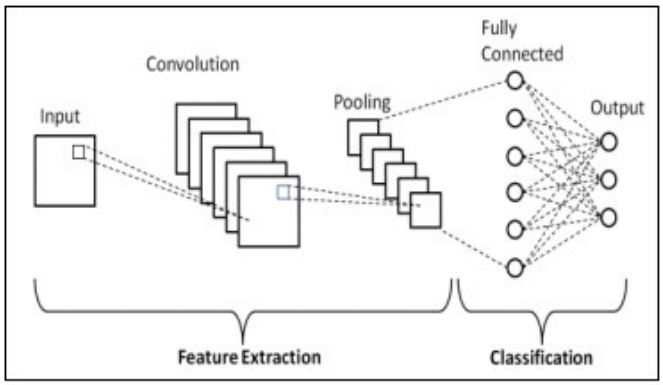

Figure 2. Arsitecture of CNN

Evaluation of CNN Models

The final stage in this research is the evaluation stage for each model on the CNN architecture. Evaluation is done by using Confution Matrix. Confusion Matrix is a visualization evaluation tool that is often used in Machine Learning where the results of columns and rows represent predicted class results and actual class results [18]. The results of evaluation calculations are carried out in three stages [19], namely; (i) accuracy, indicating the closeness of the specified size to that received; (ii) recall, looking at the level of accuracy by calculating negative errors and positive truths; and (iii) precision, determining the accuracy of measurements even though the results obtained are still far from the accepted results. When these calculations have a formula that can be seen in the following table.

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Table 2. *The Formula of Confution Matrix*

Accuracy	***Recall***	***Precision***
$ACC = \frac{TP + TN}{TP + TN + FP + FN}$	$Recall = \frac{TP}{TP + FN}$	$Precision = \frac{TP}{TP + FP}$

Result and Discussion

CNN Training and Testing Results

Following are samples of retinal fundus image data for Hypertensive Retinopathy (HR), Diabetic Retinopathy (DR), and Normal after pre-processing by removing the background.

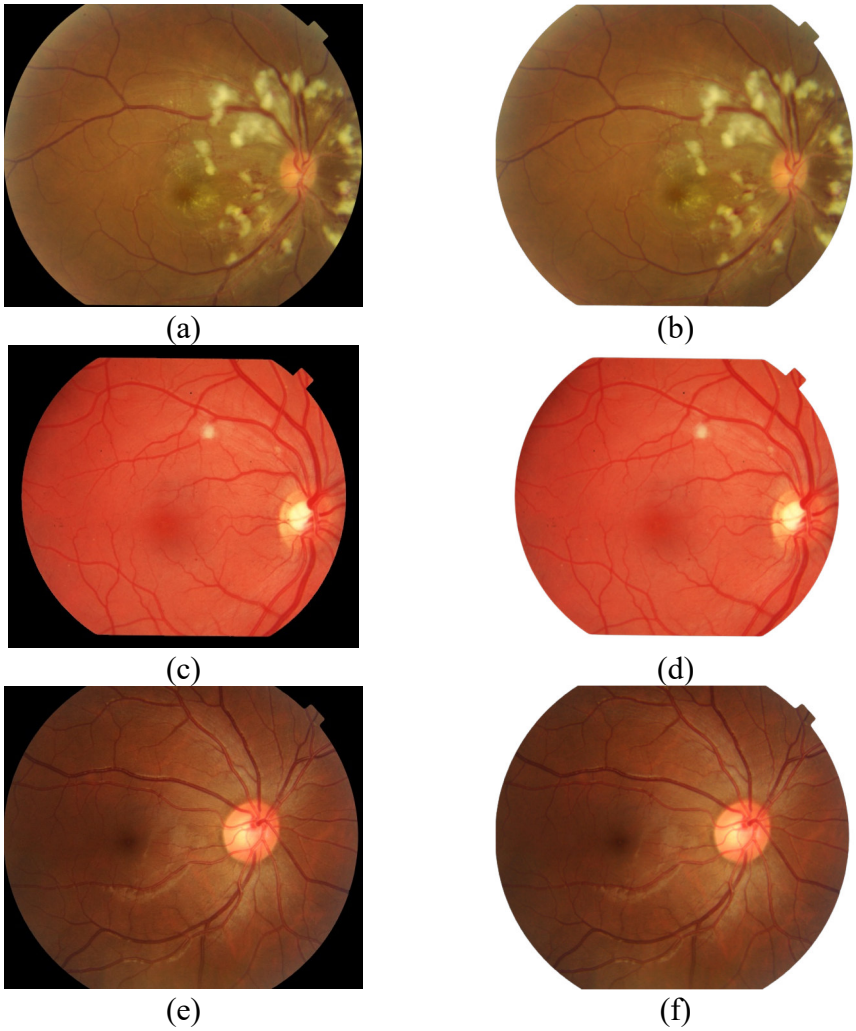

Figure 3. Retina Fundus Image (a) HR Before Preprocessing (b) HR After Preprocessing (c) DR Before Preprocessing (d) DR After Preprocessing (e) Normal Before Preprocessing (f) Normal After Preprocessing

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Before training and testing is carried out, the data is first divided into training data and testing data as shown in Table 3.

Table 3. *Sharing Data*

Types of Data	*Data Training*	*Data Testing*
Hypertensive Retinopathy (HR)	47	11
Diabetic Retinopathy (DR)	59	10
Normal	60	18

Experiments were carried out on several CNN architectures, namely AlexNet, DenseNet, Inception-V3, InceptionResNetV2, Lenet-5, MobileNetV2, ResNet50, VGG16, and VGG19. The test results can be seen in Table 4.

Table 4. *Testing Result*

Arsitektur	Precision	Recall	F1 Score	Accuracy
AlexNet	0.13	0.33	0.19	0.38
DenseNet	0.28	0.37	0.31	0.38
Inception-V3	0.80	0.78	0.78	0.79
InceptionResNetV2	0.79	0.76	0.76	0.77
Lenet-5	0.79	0.72	0.73	0.74
MobileNetV2	0.85	0.82	0.80	0.82
ResNet50	0.50	0.56	0.49	0.62
VGG16	0.87	0.85	0.84	0.85
VGG19	0.94	0.92	0.93	0.92

Table 3 shows that the best accuracy and F1 score calculation results are obtained on the VGG19 architecture.

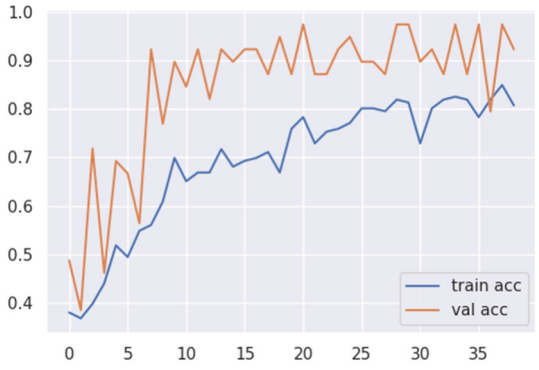

Figure 4. Testing Result of CNN with VGG19

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The results of errors in the VGG19 model during the training process can be seen in the following graph.

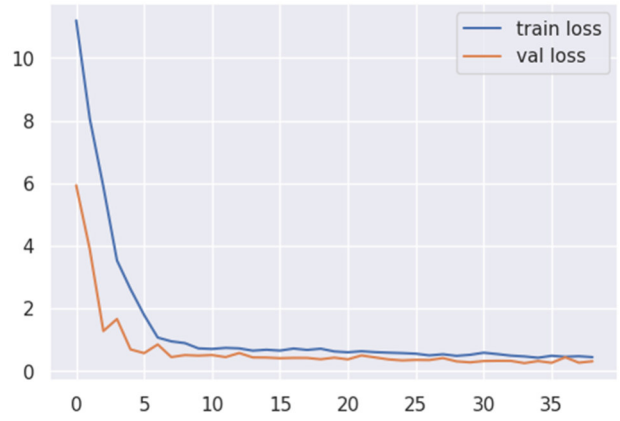

Figure 5. Result of VGG19 Architecture Error During Training Process

Validation Results of Confusion Matrix

The validation results obtained to see the success and failure of testing on the VGG19 Architecture can be seen in Figure 6.

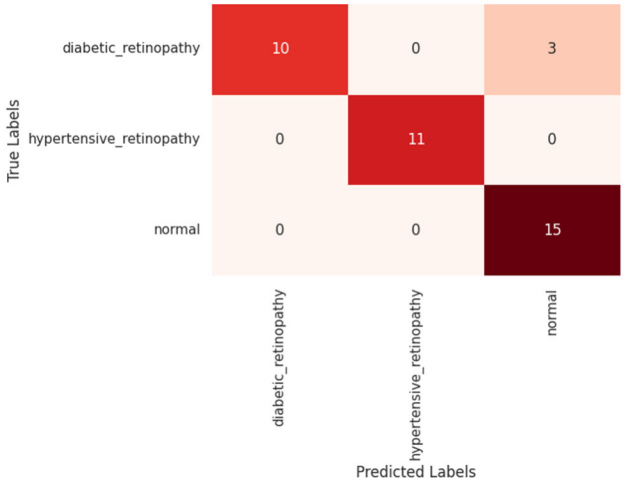

Figure 6. Validation Result of VGG19

Conclusion

Based on the results and discussion, it shows that of the nine CNN architectures tested, the VGG19 architecture obtained the highest accuracy and F1 score where the accuracy value was 0.92 and the F1 score was 0.93. In the confusion matrix it is also clear that the CNN architecture can correctly identify Hypertensive Retinopathy (HR) and Diabetic Retinopathy (DR) data, but errors still occur for normal eyes. Therefore, CNN can be used as an initial diagnostic tool to assist health workers, especially general practitioners, in diagnosing the early stages of patients suffering from Hypertensive Retinopathy (HR) and Diabetic Retinopathy (DR).

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Metaverse approach as educational tool in online learning systems

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Abstract. *This paper discusses the use of the metaverse in supporting student online learning in virtual world. Our methodology consists of applying different models through learning in the Second Life Platform to improve the student's knowledge, skills, and competencies regarding using virtual worlds for online learning purposes. Then, the Multiple Linear Regression (MLR) technique was used to examine the student's performance during their activity in the online learning process. We have found that all the student activities, such as creating content, organizing content, proposing content, and conversation feedback has a role in improving student learning abilities.*

Keywords: metaverse, multiple linear regression, online learning, student performance

Introduction

The COVID-19 outbreak has affected education systems worldwide, and the different approaches and strategies are consolidated around concepts and theories to support education to keep it going. Likewise, hardware and software innovations such as online learning systems have been built and developed that remain unchanged around content transmission, classrooms, and textbooks to support a more exciting and convenient learning model. Online learning systems are

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web-based approaches that have innovated for distributing, tracking, and managing courses over the Internet. It involves the implementation of advancements in technology to direct, design, and deliver the learning content and facilitate two-way communication between students and teachers/lecturers. They contain features such as whiteboards, chat rooms, polls, quizzes, and discussion forums that allow lecturers, students, and faculty to communicate online and share course content.

However, many studies have focused only on the online learning system's purposes and users. They noted that it often cognitively overloads students with too much work, is usually dull and teacher-directed two-way communication, and highlights the students [1]. Therefore, students often fail to relate the work to other aspects of their learning, particularly those from infield natural science, which need scientific experiments [2].

In addition, the educational event duration in online learning systems like Zoom and Google Meet is often 3 hours at maximum. Students and teachers communicate utilizing chat, and this kind of chat is based on text. The screen was quickly filled with words that the teacher typed, and sometimes students' sentences would appear when someone asked a question. The student will be confused and not know where to look if the teacher demonstrates something when they type text. So, the effect of this kind of course is not so good, and it is impossible to compare it with face-to-face teaching and learning. Thus, several previous studies argue learning online in the virtual world is quite an excellent way to perform remote education in the current online learning system [3] [4]. Students who participate in the class come from different nations and time zones, and students can give responses from the teacher in real-time regardless of what time and in what place they live [5].

On the other hand, in online learning system scenarios, the platform technology created by the metaverse has been implemented [6]. Neal Stephenson introduced metaverse or virtual world technology in his science fiction novel Snow Crash in 1992, which imagined virtual reality-based stories on the Internet. In the story, people try to escape the dullness of the natural world by exploring a digital world through several digital avatars. Since then, it has been defined and considered differently, including [3], who described metaverse technology as a 3D-based virtual world in which daily activities and economics of human life are conducted through avatars illustrating the real themselves. As cited in Ji Eun Yu [7], Huansheng Ning and her colleagues [6] further stated that the metaverse or virtual world represents a world in which virtual and reality interact and move forward for social, economic, and cultural activities are carried out in it to create value. These two definitions imply that the metaverse does not simply combine the physical and virtual worlds; it is instead a continuity of the physical world in the virtual world to create an ecosystem that merges both worlds (physical and virtual).

Despite the difference in the definition of the metaverse or virtual world, many studies have begun providing several promising plans and implementation scenarios in practices on online learning systems [6]. The increasing interest in the educational system may stem from a wide range of possibilities, including the virtual space that offers real-like representations of selves, possibly enhancing the social aspect of teaching and learning. The finding shows that it is possible to blend the lectures and guides in the virtual world with actual experiments and virtual systems as one of the components [6][8]. In the research of Jones Reinsmith et al.[8], it is noted that in blended learning, students can conduct the virtual course in the virtual world. Then, in the actual classroom, the teacher can lead the students to experiment with the class. Their model

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combines both simultaneously in online learning courses [8][9]. Therefore, to achieve the goals and vision toward for support the online learning and teaching process, this paper presented the using virtual worlds for the online learning system. Then, the student's performance is examined during their activity in the learning process.

Related Work

Potential of The Virtual World In The Online Learning Scenarios

The use of virtual worlds or metaverse for providing education and training is gathering a lot of attention. The popularity of virtual worlds for delivering education systems is partly attributed to the many benefits touted for online learning in general. According to several previous studies, virtual worlds in the online learning system describe online learning in a virtual world, creating participants a sense of reality [10] [11]. The general purpose of this scenario is to promote learning by encouraging various techniques and increasing students' level of commitment to studying the subjects[4].

The virtual world in online learning is often used in conjunction with collaborative learning or blended learning [4]. This is because using the virtual world as a social collaboration interface is where students can make connections in the virtual world and support guidance and feedback through an autonomous tutoring system based on data mining of user interactions [10].

For example, lecturers can give students some learning topics and upload teaching resources in the virtual world, and students can search for resources through virtual devices on the Internet [12].

Students can also interact with peers to share academic information through internal social networks in the virtual world, facilitating collaborative learning [12][13].

In addition, in the blended learning scenario, the findings show that virtual learning is very effective when students conduct experiments virtually, they experience the experiment as in the real world. In the research of [12][14], it is noted in online learning courses, students can conduct online learning through the metaverse (Second Life). Then, in the real classroom, the lecturers can lead the students to carry out the experiment of the subject courses, and simultaneously, the lecturers design and deliver the learning content [13].

Moreover, virtual worlds provide a realistic environment where students can learn new skills or improve on old ones. A virtual world creates a real-life education and training scenario [15]. There is no limit to the variety of real-life photo-realistic simulations students can create; thus, in education scenarios can be built to teach concepts, problems, or issues found in real life [14]. The limits are only set by the virtual world's capability to recreate realism. So, virtual worlds in education will potentially grow exponentially in recent years as technology has become more sophisticated and user-friendly.

Several studies also reported the potential for virtual worlds to enhance education is vast, and the possibilities are only limited by our imagination [5][16]. A Three-dimensional (3D) character can be used to explain the virtual world around them, and this world can be specifically designed with visual features that support the learner in achieving their training outcomes [13]. Characters and objects within the virtual world can be interacted with in order to provide a more realistic and engaging learning experience. This type of training can be very beneficial for learners who need to gain specific skills or knowledge in order to perform their job duties [5][16].

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Recently, several virtual worlds have been employed for online learning system scenarios, including World of Warcraft, Runescape, and other multi-user virtual environments, such as Second Life based on open-source software [17].

However, according to Gong and Wenyi [5], Second Life (SL) has gained the most popularity as an online learning system because of its superiority in presenting new opportunities for teaching in immersive and creative spaces. Here, we briefly introduce SL, including the OpenSim and Linden Script Language (LSL) we used in this research.

The Online Virtual World Second Life

The virtual worlds were officially released to the public by Linden Laboratory in 2003. A Virtual in Second Life is a computer-simulated virtual environment like the real world. It is usually created for its users to imagine, build, and interact with through avatars, and an avatar is the user's representation in a virtual world [18].

Like many other virtual worlds, SL can support massively multiplayer to be online simultaneously based on an open simulator (OpenSim) [18][16]. SL has three types of communication between users: chat, Instant Message (IM), and Voice over Internet Protocol (VoIP). The conversation is usually used to talk with other residents locally in a public fashion, and all the residents nearby within a certain distance can hear it. IM is used for private conversation among two or more people; others cannot listen to it even if they are nearby. SL also provides various gestures and animations to enrich communication [5].

Furthermore, most importantly, SL provides multiple online activities, including arts, science, sports, and education. The user (avatar) can explore, meet other residents, and socialize within it. Therefore, these immersive environments and applications provided by SL are essential tools in modern education practices, especially in online learning systems [5][16].

The Open Simulator

This work used Open Simulator (OpenSim) to simulate virtual environments in Second Life. OpenSim is an open source multiple platforms, multi-user based three dimensions (3D) application. It can be used to create and build a virtual environment (virtual world) that various clients can access on multiple protocols and operating systems [19]. Optional Hypergrid allows users to visit other OpenSim platforms across the website/internet from their residence or grid. In this way, OpenSim allows virtual world developers to customize their worlds using the technologies they feel work best. OpenSim runs on Windows, Mac, and Linux over the internet.

Moreover, the binary code of OpenSim is released under the Berkeley Software Distribution (BSD) license, a commercially friendly license to embed Second Life in developments. In addition, OpenSim not only aims for the Second Life server platform, but the project aims to enable the development of innovative features for the virtual world and other metaverse environments [5].

Linden Script Language

The Linden Scripting Language (LSL) is a simple and powerful language used to attach behaviors to the objects placed in Second Life. It follows the familiar syntax of a C or Java programming language style, with an implicit state machine for every script [5][20]. Multiple scripts may also be attached to the same object, allowing a small, single-function code style to

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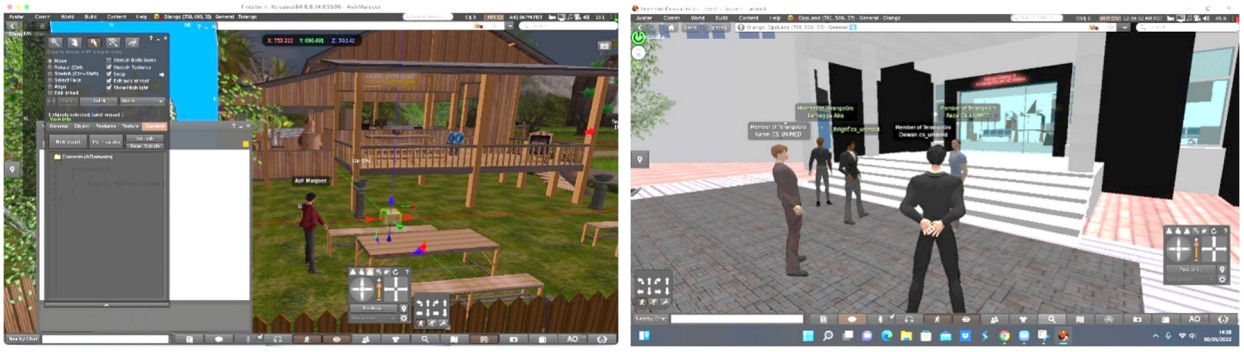
evolve, as shown in Figure 1. This leads to scripts that perform specific functions (hover, follow, etc.) and allow them to be combined to form new behaviors and environments.



(a) (b)

Figure 1. A real-life education and training scenario in metaverse
(a) The student is creating three-dimensional objects using LSL,
(b) Several students with their avatars discussing the course.

In addition, LSL allows residents of the Second Life World to program the three-dimensional (3D) objects around them. The text of the code is compiled into an executable byte code, much like Java or C programming [21]. This byte code is then run within a virtual machine on the simulator. Each code or script receives a time slice of the whole simulator time allocated to scripts, so a simulator with many scripts allows each script less time rather than degrading its own performance [5][19]. In addition, each script executes within its own chunk of memory, preventing scripts from writing into protected simulator memory or into other scripts, making it much harder for scripts to crash the simulator. With this programming, the objects built in Second Life are interactive and sense reality; therefore, adding a code enables an object to interact with the world around it [5].

Experimental Setup

Method and Data Collection

The experiment was conducted through learning a virtual world platform based on web-based, XML-RPC, and blender-free software built into Second Life. Figure 1 show that the learning scenario was developed to improve the student's knowledge, skills, and competencies regarding using virtual worlds for educational purposes in multimedia domains for one semester. In addition, lecturers were also trained to work in Second Life to develop objects and create learning projects/tools. Then, the trained lecturer passed on their knowledge and experience to the students and tested them with the designed learning products.

In an attempt to better understand how virtual worlds positively affect student learning, the student's activity in the virtual world platform was performed to estimate the student's grade. Two kinds of data were collected: students' final grades were taken from the grade book as provided by the lecturer, and student activity data refers to various learning activities in the Second Life, i.e., creating content, organizing content, proposing content, conversation feedback,

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and attendance as shown in Figure 2. The number of each action type was computed for each work student in the multimedia subject domain.

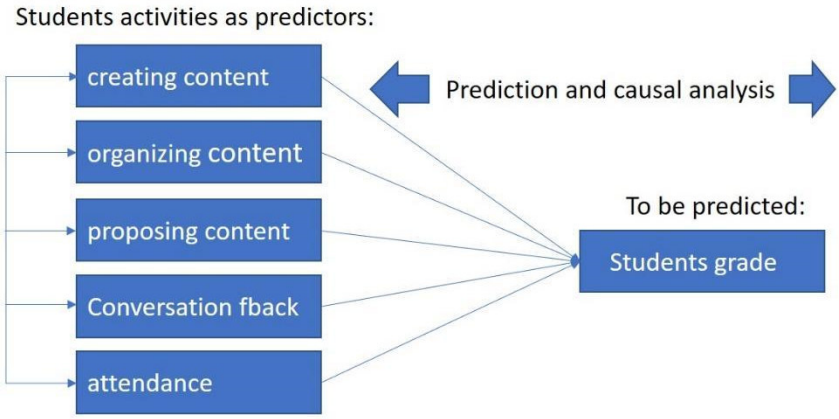

Figure 2. The diagram to visualize the proposed model

We used This evaluation technique to avoid the limitations of the explicit methods, i.e., survey or interview, such as interrupting the learning process, or users can easily falsify their feedback. Additionally, the data of learning activities in the Second Life can discover how students behaved and progressed within the virtual world environments, therefore gaining more profound insights about the whole learning process, unlike questionnaires or interviews [22]. Then, we used Multiple Linear Regression (MLR) to predict the relationship between a single dependent variable and several independent variables. The independent variable (predictor) is student activities in virtual learning, i.e., creating content, organizing content, proposing content, conversation feedback, and attendance. Meanwhile, the dependent variable (to be predicted), i.e., student grades, were taken from the student's final grade.

As shown in Figure 2, in our work, MLR is used both for prediction and causal analysis [23]. First, construct a prediction that estimates the student grade based on the observed student activities in virtual learning, i.e., creating content, organizing content, proposing content, conversation feedback, and attendance. Second, in a causal analysis, the student's activity in the virtual learning world is considered as a cause of the student's grade. In addition, the MLR's aim in this work is to detect whether a particular student activity affects the student's grade and to estimate the magnitude of this effect, if any.

Table 1. Summary statistics of the data

Parameters	N	Min	Max	Mean
Student grade	120	4.01	4.54	4.48
Creating content	120	1.79	4.45	3.77
Organizing content	120	4.17	4.54	4.48
Proposing content	120	4.09	4.52	4.43
Conversation fback	120	4.32	4.55	4.48
Attendance	120	4.32	4.55	4.54

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Table 1 shows a summary of the data used in this work. Next, we carried out a multiple regression with student parameters, i.e., (1) creating content, (2) organizing content, (3) proposing content, (4) conversation feedback, (5) attendance as predictors of student grade, and all parameters assumed to be continuous variables. Then, the numerical values of all data were normalized, so each data varied within the same range. The purpose of data normalization was to avoid cases where one variable received a high or low weight in its regression coefficient due to its initial low or large scale of measurements [24]. The normalized value of data was calculated by natural logarithm. For instance, the maximum student grade of 100 that a student could receive is 4.60, and so on.

Examining the Student Performance

Since the Multiple Linear Regression (MLR) method is used in this work, the set of actions considered was performed. The first stage, is to look for the coefficient value, which shows how significant the relationship is between the independent and dependent variables, then determine whether the independent variable in the regression model affects the dependent variable partially [23].

From the results of regression output, as shown in Table 2, the correlation is 0.974 (97%) That means that the relationship between the student grade as independent variables simultaneously strongly correlates with the student activities in virtual learning as the dependent variable. In addition, it is known that the coefficient of determination (r^2) is 0.955, which means that 95.5% of the variance of student grades is predicted by the five student activity parameters that significantly influence the value of student grades. These results are supported by the results of the F-test and T-test, which states that the student activities in the virtual learning parameters also simultaneously affect the student grades because H0 is rejected in the F and T-tests because the significance value is less than 0.05.

Table 2. Descriptive statistics from the regression output

Regression Statistics	Value
Multiple regression	0.974
Coefficient of determination (r2)	0.955
Adjusted r2	0.033
Std. Error of the Estimate	0.029
Regression (P-Value)	0.000
Regression (f)	10.660
Observation	120

The second step is to discuss individual coefficients of all dependent variables to determine whether a positive and negative correlation exists between the independent variable (student grade) and each dependent variable (student activities). The positive coefficient value means that as the independent variable's weight increases, the dependent variable's mean also increases. The negative coefficient suggests that the dependent variable decreases as the independent variable increases. Table 3 summarizes the individual testing coefficients of dependent variables and shows the obtained coefficient values (for each predictor variable). The p-value statistics are obtained by dividing the computed value of the coefficient by its standard error. This value

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estimates the likelihood that the parameter's actual value can be zero. The confidence interval is the range of values for the obtained coefficient value with the specified confidence, which means we are 95% confident that the coefficient value falls in this range.

The significant predictor value of the coefficient for each independent variable (predictor), i.e., creating content, obtained 0.83, organizing content obtained 0.75, proposing content obtained 0.63, conversation feedback obtained 0.86, and attendance obtained 0.83. This result showed that the dependent variables (student activities) correlate statistically significantly with the independent variable (student grade). Furthermore, conversation feedback as a predictor obtained a higher value than other variables. It means when students conduct online learning in the virtual world, they are very active in communicating and discussing among students and even between lecturers and students.

Moreover, values of all individual coefficients of dependent variables (student activities), i.e., creating content, organizing content, proposing content, conversation feedback, and attendance, obtained a p-value less than 0.05; we reject the null hypothesis in favor of the alternative hypothesis. At the 5% significance level, there is enough evidence to suggest a strong relationship between the dependent variable" student activities" and the independent variable" student grades," which means there is 95% confidence that the coefficient value falls in this range.

Table 3. Coefficient of regression parameter estimates

Predictor	Significant predictors	p-value
Creating content	0.83	0.017
Organizing content	0.75	0.000
Proposing content	0.63	0.055
Conversation fback	0.86	0.001
Attendance	0.83	0.008

Interpretation of Student's Performance

As discussed in Section 3.1, In this work, the dependent variable consists of several student activities as predictors, i.e., creating content, organizing content, proposing content, conversation feedback, and attendance. Meanwhile, student grade is a single independent variable to be predicted with an entire dataset (n = 120). We next calculated the average prediction accuracy (apa) for the final student as follows:

$$apa = \frac{n}{1} \cdot \sum_{i=1}^{n} \left| \frac{p_j - a_j}{a_j} \right| x100\% \text{.....(1)}$$

Where n is the total number of prediction results; p_j is the predicted student grade score of the a_j all students in the class (j = 1 to n); and a_j is the actual value of student grade score of the a_j student. The higher the average prediction accuracy, the better the model. This percentage is calculated as the number of good predictions divided by the total number of prediction results.

Using equation 1, we obtained the average prediction accuracy of the total prediction results, which varies within only 3% with a minimum value of .4,1, and the percentage of good predictions varies within 97% with a minimum value of 4.38. Moreover, based on these results, we classify the student grade using the Relative Score Index (RSI) as shown in Table 4, RSI

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criterion divides the interval of minimum and maximum value of the prediction result, i.e., 4.1 to 4.38, into four equal parts: Excellent, Very Good, Good, and Average.

Table 4. Relative Score Index (RSI) of student grade

RSI	Criteria	Level Performance
If student grade ≥ 4.5	A	Excellent
If student grade ≥ 4.38	B	Very Good
If student grade ≥ 4.25	C	Good
If student grade < 4.25	D	Average

Note: The actual value of student grade (RSI) was normalized using the natural logarithm

Result and Discussion

Our primary aim in the research reported in this paper was to develop online learning through the virtual world in which we could say the student performance and tell which area a student's aptitude, talents, and interests which a student did relatively better. To accomplish this work, the following objectives were pursued: rank the overall performance of students, determine the impact of online learning in the virtual world, and determine how many students are relatively better. Therefore, the student's academic performance in learning activities and behavior in the second life is predicted using the Multiple Linear Regression method. Table 5 presents the classification of students' performance based on the RSI values. Then, we use a criterion that divides the interval 4.1 – 4.38 into four equal parts and gives the number of students falling within each category. We obtained results from the classification: thirty-three (33) students performed excellently, seventy-five (75)students had an excellent performance, Six (6) students had a good performance, and six (6) students also performed averagely.

Table 5. Classification of students overall performance

Performance	Count of Student	Percentage (%)
Excellent	33	0.28
Very Good	75	0.63
Good	6	0.05
Average	6	0.05
Total	120	1.00

Moreover, it can be seen in Section 3 Table 2 that predictor has a very significant value to the prediction of student scores, i.e., creating content obtained 83%, organizing content obtained 75%, proposing content obtained 63%, and conversation feedback obtained a higher value 86%. Suppose we consider the highly significant results from the conversation feedback variable as predictors of the student's grades. In that case, it indicates that students actively participate in online learning virtual worlds. It means learning in virtual worlds, such as Second Life, can offer to teach in immersive and creative spaces.

Learning online in the metaverse can facilitate socialization and collaborative activities to explore student talents and interests. In blended learning environments it can also support the student learning process; for example, activities or experiments that may not be feasible or are too difficult to carry out in real life a student can conduct in the virtual world [9]. Thus, from the

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results in Tables 2 and 3, we can conclude that online learning through the virtual world could improve student performance.

Conclusion and Future Work

Determining the factors affecting students' academic performance is an exciting task since it will help educators enhance their online learning and teaching process. In this context, we have proposed an online learning model in the metaverse, and then we examined the students' grades using their activity in the online learning process. Our methodology consists of applying different models through learning a virtual world platform.

A learning system was developed to improve the student's knowledge, skills, and competencies regarding using virtual worlds for educational purposes. After predicting the performances of students' grades using their activity in learning online, such as creating content, organizing content, proposing content, and conversation feedback, we have found that all of the activity has a role in improving student learning abilities.

In addition, the limitation of this work is that it uses a small data set and only focuses on one student subject. Therefore, in future work, we would like to use a large dataset that records Medan State University students' attributes with different subjects to identify the factors that influence their performance on online learning in the virtual world (Second Life). Also, we would like to compare the performance of the multiple regression techniques with other regression and classification techniques.

Acknowledgments

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Classification of hair disease using cnn with VGG-16 architecture

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Abstract. *Hair diseases are common and can be caused by various factors, including genetics, stress, malnutrition, sun exposure or air pollution. Accurate diagnosis of hair diseases is important for proper treatment, but it is a challenging task due to overlapping symptoms. A CNN-based approach is expected to assist healthcare professionals in accurately diagnosing hair diseases and providing targeted treatment. This research aims to develop a hair disease classification system using convulsive neural networks (CNN). This research uses a dataset of hair disease images obtained from Kaggle, which are annotated and organized based on different types of hair diseases. Experiments were conducted using hair disease image data with 15 epochs on a CNN Deep Learning model with VGG-16 architecture, and resulted in an accuracy of 94.5% and a loss rate of 18.47%, with a test epoch time of 9 hours 48 minutes. The results of this study show that the convulsive neural network (CNN) with VGG-16 architecture can successfully classify 10 types of hair diseases.*

Keywords: CNN, hair diseases, VGG-16

Introduction

Head hair is a part of the human body that has an important role in determining the beauty and appearance of a person. Head hair has a shape similar to strands and grows on the human scalp containing a lot of keratin, and can emerge from the epidermal layer [1]. About 5 million hair

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follicles are present throughout our body [2]. Scalp hair maintains body temperature and protects the brain from external heat. The typical hair growth cycle runs for 2-7 years, according to Patel et al. [3] and Wolff, Fischer, and Blume-Peytavi [4]. A healthy and strong hair condition is certainly desired by many people. However, just like other body parts, hair is also susceptible to various diseases and damage. Some examples of hair diseases include alopecia, telogen effluvium, and scalp psoriasis.

Diseases and damage to the hair can be caused by many factors, such as improper care, sun exposure, air pollution, genetics, stress, and lack of balanced nutritional intake. Treatment of hair diseases requires an accurate and precise diagnosis in order to provide the right treatment. However, diagnosis of hair diseases can be a challenge because often the symptoms of hair diseases are similar to each other. Therefore, there is a need for a hair disease classification system that can help doctors and health professionals diagnose hair diseases with a reliable and accurate diagnosis.

In recent years, deep learning technologies, particularly convolutional neural networks (CNNs) have brought revolutionary success in the detection of deadly diseases. To date, neural networks assist health professionals in the early detection of various types of tumors and cancers, such as stomach cancer (adenocarcinoma) [5], skin cancer (melanoma) [6], and brain tumors (glioblastoma) [7]. Neural networks can also be applied in detecting life-threatening dengue fever [8] and covid-19 [9]. In one study, CNNs were used to extract complex temporal dynamic features from heart rate variability (HRV) signals, developing an algorithm that facilitates early detection of diabetics [10]. In [11], the Convolutional Neural Network (CNN) method with VGG-19 architecture successfully identified eye diseases. In this study, we will present an approach using CNN to classify hair diseases based on images that represent various types of hair diseases. This approach is expected to help doctors in making an accurate diagnosis and providing more targeted treatment. In addition, this method can also facilitate the public in detecting hair diseases and taking the necessary preventive measures.

Methods

This research is an experimental research with stages in the process of work that can be seen in Fig. 1.

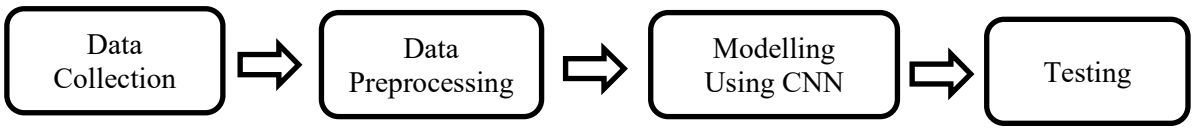

Figure 1. Phases of Research

Collection of Data

The most challenging part of using visual images for disease prediction and disease classification is data collection. Often, the number of images suitable for a particular disease is very small. Moreover, the images are scattered across the internet. In this study, the authors extracted images from Hair Diseases | Kaggle.

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Tabel 1. The number of sample data from each hair disease

Diseases	Sample
Alopecia Areata	400
Contact Dermatitis	400
Folliculitis	400
Head Lice	400
Lichen Planus	400
Male Pattern Baldness	400
Psoriasis	400
Seborrheic Dermatitis	400
Telogen Effluvium	400
Tinea Capitis	400

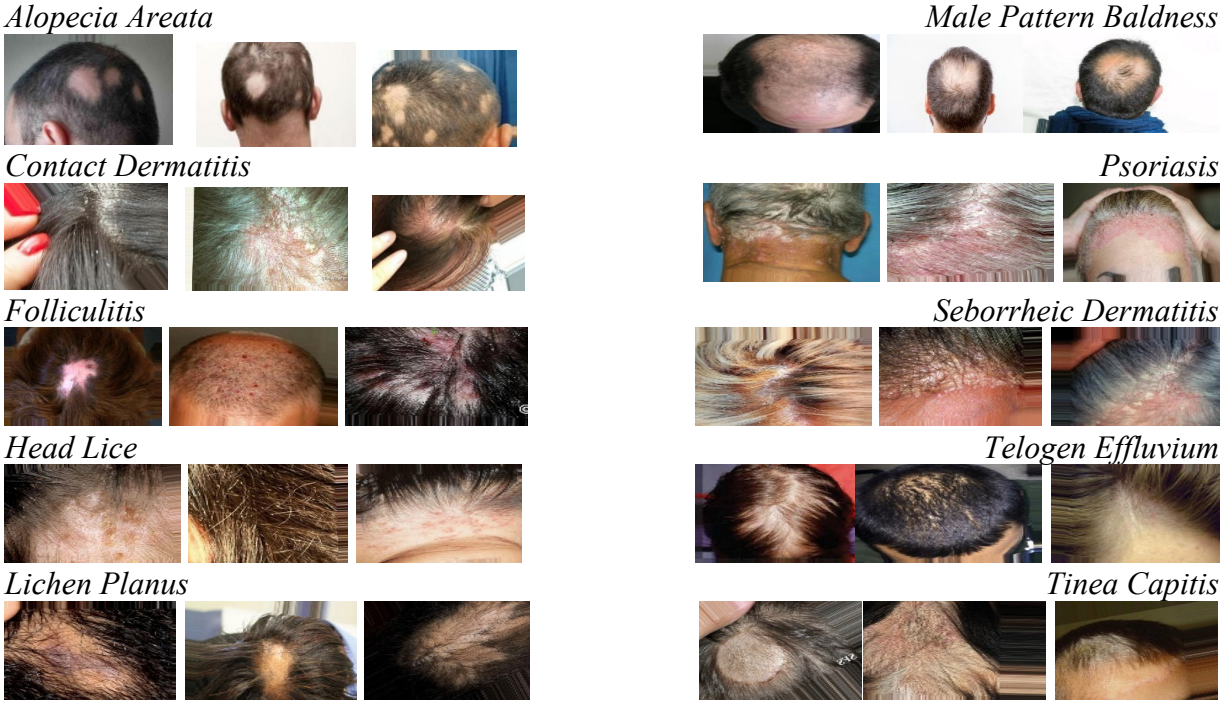

Figure 2. Types of hair diseases

Data Preprocessing

Preprocessing is one of the procedures that must be performed on data to perform the initial process. Sometimes the available data contains various problems that can hinder the results of the process. Preprocessing is one of the stages of eliminating problems that can interfere with the results of data processing [12]. In this research, preprocessing goes through two stages, namely resizing the image of skin hair disease from the previous size, where the unequal size of the image is changed to 224 x 224 pixels and also the coloring stage [16]. Preprocessing Coloring is useful for changing the color of the image, therefore it can clarify the object to be processed, in this study the object is hair disease.

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CNN Algorithm

At this stage, the author will apply the CNN algorithm with VGG-16 architecture to human hair disease. This stage will be implemented in the form of a programming language, Python, using the Jupyter Notebook plugin in the Google Collaboratory text editor.

At this stage, several parameters of the algorithm will be changed so as to produce a model which is then used to get the best level of accuracy in classifying diseases in the human eye using the Deep Learning Model. The Deep Learning model used for this research is classification with Convolutional Neural Network (CNN) [10]. Convolutional Neural Network (CNN) is a deep learning model that is included in supervised learning. Classification Supervised Learning is a classification model with a class label. There are two main components in the Convolutional Neural Network, namely:

Convolutional Layer

The Convolutional Layer is the core of the Deep Learning Convolutional Neural Network model, the convolution kernel is used to extract features from the input image. This process converts the next layer of pixels into the receptive field of the connected area of any convolution kernel on the input image.

Pooling Layer

The Pooling Layer performs downsampling to improve image feature extraction by minimizing the dimension of the feature map and the number of parameters in the network as well as speeding up computation to control overfitting.

Softmax

Softmax Activation is another description of Logistic Regression that can be utilized for clustering more than two classes [13]. Softmax is useful for converting the output of the last layer into its basic probability distribution. Here is the softmax activation equation:

$$fi(\vec{x}) = \frac{e^{x_i}}{\sum_{j=1}^{k} e^{x_j}} \quad (1)$$

In the above equation, the notation fi is included, which is the result of the function on each i-th element in the output class vector. Meanwhile, x is a vector containing the values obtained from the last fully connected layer. Softmax can also measure the probability of each class which will then be taken as a real-valued vector and converted into values with zero to one limits, which when added together will add up to one [14].

Table 2. Description of the CNN model used

Layer (type)	*Output Shape*	*Parameters*
conv2d (Conv2D)	(*None*, 150, 150, 32)	2432
max_pooling2d (Maxpooling2D)	(*None*, 75, 75, 32)	0
conv2d_1 (COnv2D)	(*None*, 75, 75, 64)	18496
max_pooling2d_1 (Maxpooling2D)	(*None*, 37, 37, 64)	0
conv2d_2 (COnv2D)	(*None*, 37, 37, 96)	55392

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max_pooling2d_2 (Maxpooling2D)	(*None*, 18, 18, 96)	0
conv2d_3 (COnv2D)	(*None*, 18, 18, 96)	83040
max_pooling2d_3 (Maxpooling2D)	(*None*, 9, 9, 96)	0
flatten (Flatten)	(*None*, 7776)	0
dense (Dense)	(*None*, 512)	3981824
activation (Activation)	(*None*, 512)	0
Dense_1 (Dense)	(*None*, 5)	2565

Result and Discussion

Data Preprocessing

All acquired hair disease image data is preprocessed such as data resizing and data coloring as shown in Fig. 3.

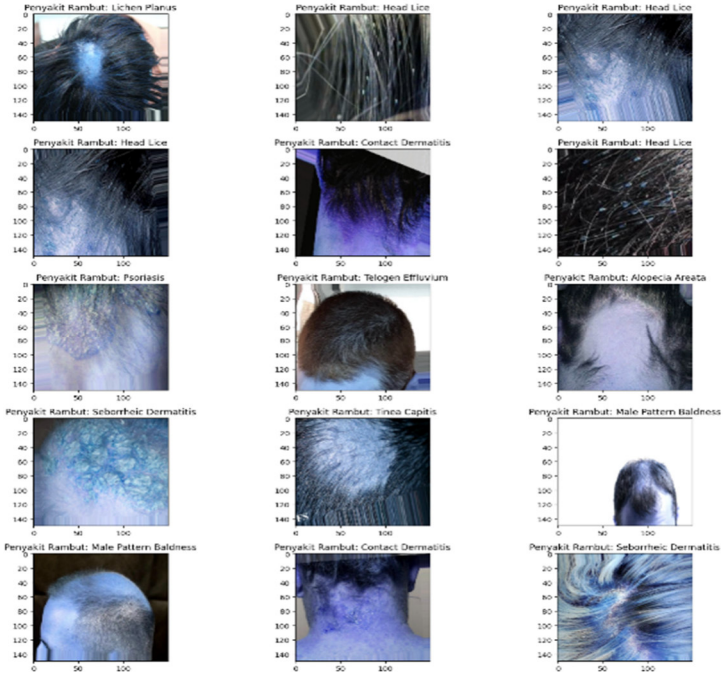

Figure 3. The result of preprocessing

Results of Data Prediction

The prediction result in Fig. 4 is the result of detecting the accuracy of hair disease with confusion matrix. It can be seen from Fig. 4, the prediction results achieved an accuracy of 94.5%, with a classification error of 0.55%. In addition, it can also be seen that for Alopecia Areta disease does not experience misclassification or correctly predicted data. For Contact Dermatitis disease, there were 2 misclassifications and predicted Head Lice disease and 38 other data were correctly predicted. Folliculitis disease does not experience misclassification or correctly predicted data. Head Lice disease does not experience misclassification or correctly predicted data.

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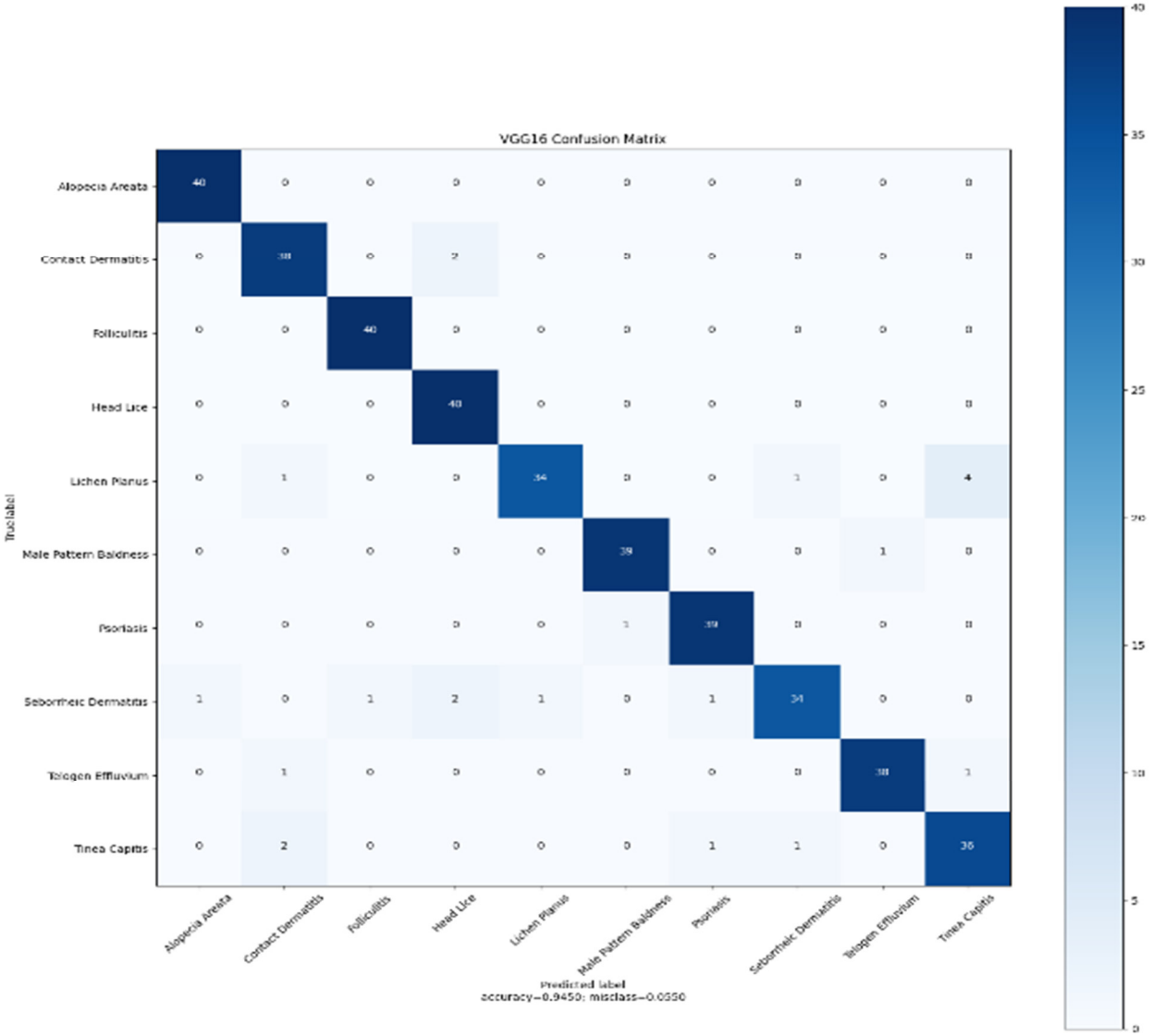

Figure 4. Prediction results using confusion matrix

Lichen Planus disease experienced misclassification and predicted Contact Dermatitis disease as much as 1, predicted Seborrheic Dermatitis disease as much as 1, predicted Tinea Capitis disease as much as 4 and 34 other data were correctly predicted. Male Pattern Baldness disease has misclassified and predicted Telogen Effluvium disease as much as 1, and 39 other data are correctly predicted. Psoriasis disease has misclassified and predicted Male Pattern Baldness disease as much as 1, and 39 other data are correctly predicted. Seborrheic Dermatitis disease experienced misclassification and predicted Alopecia Areta disease as much as 1, predicted Folliculitis disease as much as 1, predicted Head Lice disease as much as 2, predicted Lichen Planus disease as much as 1, predicted Psoriasis disease as much as 1 and 34 other data predicted correctly. Telogen Effluvium disease experienced misclassification and predicted Contact Dermatitis disease as much as 1, predicted Tinea Capitis disease as much as 1 and 38

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other data were correctly predicted. Tinea Capitis disease has misclassified and predicted Contact Dermatitis disease as much as 2, predicted Psoriasis disease as much as 1, predicted Seborrheic Dermatitis disease as much as 1 and 36 other data correctly predicted.

Testing

Experiments conducted using hair disease image data with 15 epochs on the Deep Learning CNN model with VGG-16 architecture and the resulting accuracy value is 94.5% and the loss rate is 18.47% with an epoch testing time of 9 hours 48 minutes as in Fig. 5.

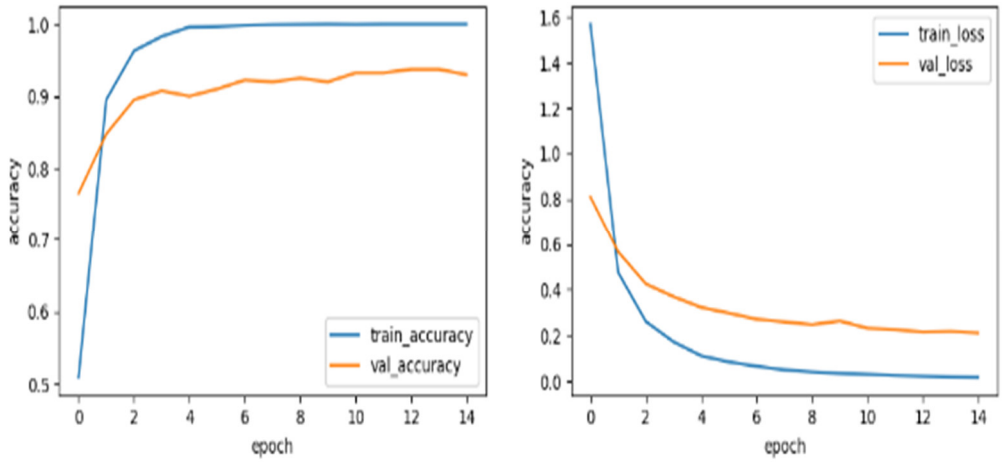

Figure 5. *Accuracy and Loss Value of Hair Disease*

Conclusion

Classification of Hair Disease Types applying CNN algorithm with VGG-16 architecture uses 10 types of Hair disease, namely Alopecia Areata, Contact Dermatitis, Folliculitis, Head Lice, Lichen Planus, Male Pattern Baldness, Psoriasis, Seborrheic Dermatitis, Telogen Effluvium and Tinea Capitis. The hair disease data is obtained from Kaggle.com as much as 4000 data, which is divided into 3, training data, testing data and validation data. From the application of the CNN algorithm with VGG-16 architecture, this study obtained an accuracy of 94.5%, a classification error of 0.55% with an epoch testing time of 9 hours 48 minutes.

Acknowledgments

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Optimizing Product Distribution Processes in Online Business Using Data-Driven Models

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Abstract. The development of information and communication technology has transformed the global business paradigm, particularly in the e-commerce sector. This study investigates the impact of implementing a Data-Driven model on the distribution of e-commerce products, focusing on enhancing efficiency, accuracy, and responsiveness. It is revealed that this model improves order collection accuracy, optimizes delivery routes, and enables real-time inventory management. The distribution performance evaluation includes positive customer responses, a deeper understanding of consumer preferences, increased engagement levels, positive effects on sales performance, and alignment with the company's strategic goals. Compared to traditional models, the Data-Driven model demonstrates increased operational efficiency, improved customer responsiveness, high prediction accuracy, flexibility, and adaptability. While initial operational costs may be higher, long-term benefits and alignment with technological developments are crucial considerations.

Keywords: E-commerce, Data-Driven, Product Distribution

Introduction

The development of information technology has comprehensively altered the business paradigm, particularly in the context of online or e-commerce businesses. In tandem with this progression, online businesses have become an inevitable economic force, playing a pivotal role in providing

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global access to various products and services. This phenomenon has instigated significant changes in the way consumers engage in shopping, wherein transactions can take place without geographical or temporal constraints.

In this context, product distribution emerges as a critical element that influences the success of e-commerce companies. Despite the facilitation of online transactions by technology, challenges in product distribution remain a hurdle that needs to be overcome. Delivery delays, inventory uncertainties, and high logistical costs are some of the issues that arise and require serious attention [1].

This study highlights that factors such as delivery time can have a significant impact on online consumer purchasing decisions. Slow or unpredictable deliveries may result in decreased sales and customer satisfaction. Therefore, it is crucial for e-commerce companies to scrutinize their product distribution processes.

The importance of efficient and timely distribution underscores that e-commerce companies should not only focus on attractive product offerings but also on how these products reach consumers. Improving distribution efficiency can provide a significant competitive advantage [2].

This study indicates that timely delivery can significantly influence consumer purchasing intent. Timely delivery is not only a necessity but can also be a strong differentiation factor in the competitive e-commerce market.

The rapid growth of e-commerce has had a significant impact on the way business is conducted, particularly in terms of product distribution. An efficient and reliable distribution process is a crucial element ensuring the sustainability and competitiveness of e-commerce companies amid increasing competition. In this context, optimizing product distribution becomes crucial for enhancing customer service, minimizing logistical costs, and addressing complex challenges in the e-commerce supply chain.

One way to optimize the supply chain of online businesses is by leveraging technology. Technology can be employed in various aspects of online businesses, such as inventory management, selecting appropriate shipping methods, and monitoring and analyzing customer data. By harnessing technology, companies can enhance the performance of their supply chains, reduce operational costs, and provide a better shopping experience for customers.

Previous research has highlighted several key aspects related to product distribution in online businesses. A study by [3] revealed that delivery time directly impacts online sales. Slow deliveries can reduce customer satisfaction and hinder e-commerce business growth. This indicates that delivery time is not only an operational parameter but also a critical element influencing consumer purchasing decisions.

Sunil [4] outlined that supply chain management has become a vital concept in today's business world. The core of supply chain management is the distribution process, which involves moving and storing goods from the supplier level to the customer level within the supply chain. Optimal distribution is key to a company's success in conducting business, as the distribution process directly impacts supply chain costs.

Some studies have employed particle swarm optimization to solve three-tier supply chain problems, as seen in the research conducted by [5], [6], and [7]. Simulation techniques have also been utilized to address supply chain issues, as demonstrated by Yoshizumi [8]. Recent research

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conducted by [9] solved a two-tier distribution case using the bees algorithm.

Theoretical Basis

The supply chain is a network of companies that collaboratively work to create and deliver a product to end-users. These companies typically include suppliers, manufacturers, distributors, retail stores, and supporting entities such as logistics service providers [10]. The supply chain is oriented towards both the upstream and downstream aspects. Upstream involves relationships among sub-suppliers, suppliers, and manufacturers, while downstream encompasses the manufacturer, distribution center, wholesalers, retailers, and customers [11]. The supply chain's focus on both upstream and downstream aspects is illustrated in Figure 1."

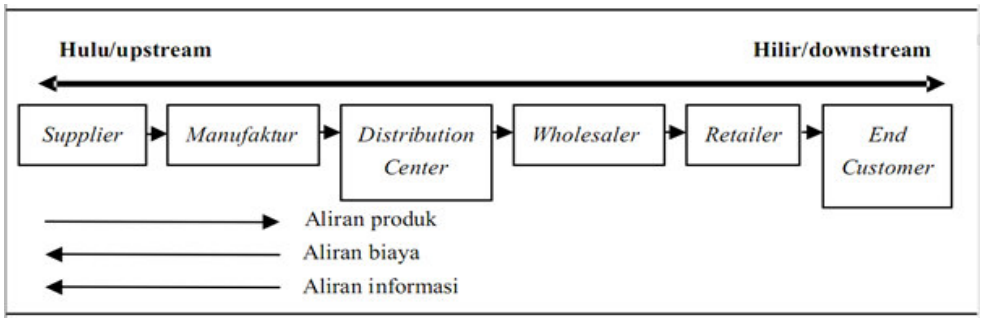

Figure 1. Supply chain structure (Source: [11])

The supply chain levels according to [12] are shown in Figure 3.1. Figure 3.1 is a single product model between echelons (levels). The three-level distribution system in this research only involves manufacturers, distributors, wholesalers and retailers.

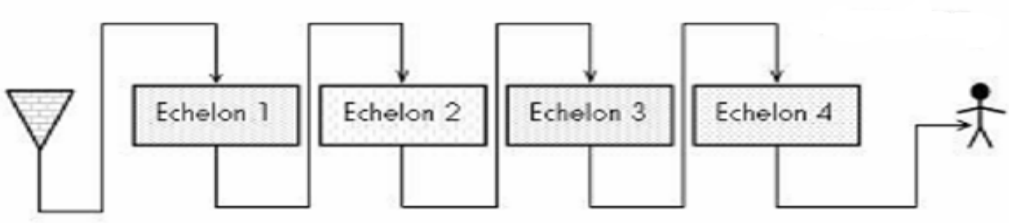

Figure 2. Supply chain flow of goods (source: [12])

The supply chain levels according to Marquez [12] are shown in Figure 2. Figure 2. is a single product model between echelons (levels). The three-level distribution system in this research only involves manufacturers, distributors, wholesalers and retailers.

The three-tier distribution system from manufacturing to retail is illustrated in the example provided in Figure 3. There are two manufacturers, each capable of sending goods to any distributor in a specified quantity. Each manufacturer has production capacity.

Each distributor can dispatch goods to any wholesaler in a designated quantity based on its capacity. In this context, the distributor will have a warehouse as a storage facility for the

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goods it will distribute.

There are three wholesalers in Figure 3, capable of delivering goods to three retailers according to the retailers' demands.

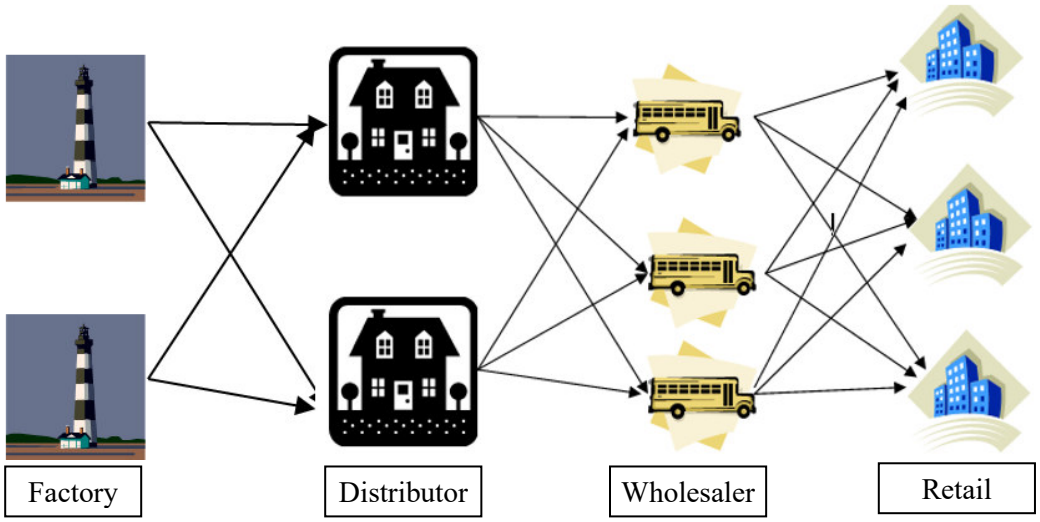

Figure 3. Example of a three-level distribution

The constraints within this three-tier distribution system are as follows:

Manufacturing capacity constraint is depicted in Equation (1).

$$\sum_{i=1}^{s} X_{ij} \leq S_i \quad (1)$$

with:
S_i represents the manufacturing capacity of i
X_{ij} represents the quantity of goods shipped from manufacturing i to distributor j

The distributor capacity constraint is depicted in Equation (2).

$$\sum_{j=1}^{p} X_{jk} \leq S_j \quad (2)$$

with:
S_j represents the capacity of distributor j
X_{jk} represents the quantity of goods shipped from distributor j to wholesaler k

The wholesaler capacity constraint is depicted in Equation (3).

$$\sum_{k=1}^{q} X_{kl} \leq S_k \quad (3)$$

With:
S_k represents the capacity of wholesaler k
X_{kl} represents the quantity of goods shipped from wholesaler k to retailer l

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The retailer demand constraint is depicted in Equation (4).

$$\sum_{k=1}^{q} X_{kl} = D_l \quad (4)$$

With:

D_l represents the demand of retailer l

X_{kl} represents the quantity of goods shipped from wholesaler k to retailer l

Result and Discussion

Analysis of Product Distribution Process

In this section, we will delve more deeply into the results of the analysis of the product distribution process in an e-commerce company that has implemented a Data-Driven model. Each distribution stage will be analyzed to understand the changes that occur after the implementation of this model.

1. Order Collection and Processing

The analysis begins with the first stage of the distribution process, which is order collection and processing. The case study reveals that the Data-Driven model has enabled the company to improve the accuracy of order collection through the analysis of historical data and demand predictions. Consequently, the accuracy of orders received by customers has significantly increased.

2. Determination of Optimal Delivery Routes

The next stage is determining optimal delivery routes. The implementation of the Data-Driven model allows the company to analyze variables such as traffic conditions, weather, and fleet availability more precisely. As a result, delivery routes can be optimized to minimize delivery time and logistic costs.

3. Real-Time Inventory Management

An essential aspect of product distribution is real-time inventory management. The Data-Driven model provides the ability to monitor inventory directly, identify demand patterns, and respond to market changes more quickly. This helps the company maintain optimal inventory levels, reducing the risk of stockouts or excess inventory.

4. Impact on Productivity and Operational Costs

Changes in the distribution process also impact productivity and operational costs. Operational data analysis indicates that the implementation of the Data-Driven model can enhance employee productivity through the automation of routine tasks and faster decision-making. Additionally, optimizing distribution processes helps reduce overall operational costs.

Through in-depth analysis at each stage of the product distribution process, this research provides a comprehensive overview of how the Data-Driven model effectively enhances efficiency, accuracy, and responsiveness in the distribution of e-commerce company products.

Distribution Performance Evaluation

This section will comprehensively review the evaluation of product distribution performance after the implementation of the Data-Driven model in the e-commerce company.

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This evaluation includes critical aspects reflecting the impact of changes in product distribution on customer response and operational efficiency.

1. Customer Response to Distribution Changes

Analysis of customer response becomes a primary focus in the evaluation of distribution performance. Surveys and interviews with customers indicate that the majority experience increased satisfaction with faster and more accurate delivery times. This positive response is also reflected in increased customer loyalty and purchase frequency.

2. Understanding Consumer Preferences

Through the evaluation of distribution performance, the company can gain a deeper understanding of consumer preferences. Consumer data analysis enables the identification of purchasing trends, preferred delivery times, and favored delivery methods. This understanding forms the basis for personalized customer experiences.

3. Level of Customer Engagement

The evaluation of distribution performance also considers the level of customer engagement after changes in the distribution model. The launch of real-time delivery notifications, interactive order tracking, and distribution-related loyalty programs are factors that enhance customer engagement. This creates a closer relationship between the company and its customers.

4. Impact on Sales Performance

Distribution performance evaluation also includes the influence of these changes on overall sales performance. Post-implementation sales data of the Data-Driven model will be analyzed to assess whether distribution changes contribute to increased revenue and company profitability.

5. Alignment with Company Strategic Objectives

Finally, the evaluation of distribution performance will be assessed based on alignment with the company's strategic objectives. Changes in the distribution of products must align with the company's vision and mission, contributing positively to long-term goal achievement.

Through a thorough evaluation of each aspect of distribution performance, this section provides a comprehensive understanding of the impact of the Data-Driven model implementation on customer response and operational efficiency in an e-commerce company.

Comparison with Traditional Models

The comparison with traditional models will evaluate and contrast the performance of product distribution using the Data-Driven model with traditional distribution models that may have been used previously in the e-commerce company. This comparison will detail differences in efficiency, customer response, and other key aspects between the two models.

1. Operational Efficiency

The Data-Driven model often provides a significant improvement in operational efficiency compared to traditional distribution models. Historical data analysis and the use of artificial intelligence enable the company to optimize each stage of the distribution process, reducing delivery time and avoiding overstock.

2. Customer Response

Comparison with traditional models will highlight differences in customer response to distribution changes. The Data-Driven model, with its ability to personalize the customer

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experience, often creates a more positive response. Conversely, traditional models may be less responsive to the individual needs and preferences of customers.

3. Accuracy of Predictions and Decision-Making

In this comparison, the accuracy of predictions and decision-making capabilities between the Data-Driven model and traditional models will be evaluated. The Data-Driven model, with more sophisticated data analysis, tends to provide more accurate predictions and support more informed decision-making.

4. Flexibility and Adaptability

The Data-Driven model often exhibits better flexibility and adaptability to changes in the market and company policies. This comparison will evaluate the extent to which both models can quickly and effectively adjust their distribution strategies to changes in the business environment.

5. Operational Costs

Operational costs between the Data-Driven model and traditional models will be thoroughly evaluated. While the implementation of the Data-Driven model may require a larger initial investment, a long-term comparison of operational costs will provide an overview of relative efficiency and long-term benefits.

6. Alignment with Technological Developments

The comparison will involve the alignment of both models with the latest technological developments. The Data-Driven model is often more easily integrated with the latest technologies, such as artificial intelligence and big data analysis. Traditional models may require more significant adjustments to remain relevant.

7. Environmental Impact

Environmental aspects will also be part of this comparison. The Data-Driven model can contribute to energy efficiency and waste reduction through distribution optimization. Traditional models may not have the same focus on environmental sustainability.

Conclusion

This research makes a significant contribution to the scholarly literature by documenting the tangible impact of implementing the Data-Driven model in the distribution of e-commerce products. Its practical implications include providing guidance for e-commerce companies in designing data-driven distribution strategies to enhance efficiency and customer satisfaction. Overall, this research yields robust findings regarding the potential and benefits of the Data-Driven model in the context of product distribution in online businesses. By combining in-depth analysis and detailed case studies, this research establishes a solid foundation for further development in this field. Through the insights gained from this research, it is anticipated that e-commerce companies can leverage the Data-Driven model to achieve competitive advantages and deliver added value to their customers.

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The effect of inquiry-based module with sets (science, environment, technology and society) integrated into dynamic fluid material

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Abstract. *The development of science and technology have given impact towards the improvement of learning system became based on 21st century skills. However, currently 21st century skills of student is not optimal yet, and one of the cause is the weakness factor of teaching learning used. In general, physics teaching material used does not have optimal visualization and less support the independent learning process, so that implicated towards the low student learning outcomes. The purpose of this research was to determine SETS (Science, Environment, Technology, and Society) integrated inquiry based module on dynamic fluid material. The applied approach in this research was mixed method, so that data analyzed qualitatively and quantitatively. Based on the research result, the developed teaching material was stated valid and obtain 83,85% by material expert and 81,48% by media expert. Student obtained an average pre-test score of 35,83 and an average post-test score of 93,89. The average N-gain score obtained was 0,9 or 90,48%, which was categorized high. Thus, modul was stated feasible, very practical, and effective to enhance students' understanding of dynamic fluid material.*

Keywords: Teaching Material, Dynamic Fluid, Inquiry, SETS

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Introduction

The ever-evolving science and technology in the 21st century have become one of the factors in the development of the education system globally, which then affects teaching and learning methods [1]. Technological developments have a strong influence on changes in the education system and encourage the improvement of digital capabilities in every educational person, both students, and teachers. Learning in the 21st century has encouraged the development of various competencies needed to thrive in a complex world with its various interconnected sectors [2].

Examples of 21st-century skills that are currently needed are digital literacy, inventiveness, emotional awareness, critical thinking, and problem-solving [3]. The 21st-century skills are important competencies in learning and innovation, and are believed to help students thrive in the digital age and global interconnection [4]. Improving the quality of the learning process to fit the needs of the 21st century is an effective way to improve students' abilities in the 21st century. However, the quality of 21st-century skills-based learning in Indonesia is currently still not optimal, resulting in students' 21st-century skills also not being optimal, one of which is critical thinking ability [5].

The critical thinking ability of students in schools today is still modest, and needs to be developed. Students' critical thinking abilities are influenced by many factors, such as learning approaches, teaching materials, learning styles, learning facilities, and other factors used inside and outside school [6].

One of the efforts to improve the quality of learning that can support students to improve their critical thinking ability is the inquiry approach. Inquiry-based learning can improve cognitive abilities so that it can improve the quality of the process and student learning outcomes [7]. Inquiry-based learning is an effective approach to increasing students' curiosity and motivation to learn. Both internal factors have the potential to help students improve their ability to work in complex and unpredictable environments and will encourage students to be more critical and active in the learning process [8]. These skills have a major impact on student learning development, and can improve thinking, analysis, and problem-solving skills in learners [9]. The improvement of inquiry skills in students will also encourage the improvement of other abilities so that students' adaptive abilities and productivity also develop [10]. These abilities will help students in facing various 21st-century challenges. Therefore, inquiry-based learning can significantly improve student learning outcomes.

Another factor that affects student learning outcomes is student learning style. Educator needs to pay attention to strategic learning based on students' learning and cognitive styles. Therefore, it can be stated that students' learning styles affect the absorption of material that students can understand [11]. Dynamic fluid is one of the physics materials that has many applications in daily life [12].

Based on the results of observations that have been carried out at SMA Negeri 2 Kisaran, it is found that students have very diverse learning styles. 50% of the total students observed had a kinesthetic learning style. 16.67% of the total students have a visual learning style. 6.67% of the total students have an auditory learning style. 16.67% of the total students have visual and kinesthetic learning styles. 6.67% of the total students have auditory and visual learning styles. 3.33% of the total students have kinesthetic and auditory learning styles.

In supporting an effective learning process, student learning facilities need to be optimized based on student learning styles, one of which is by developing teaching materials that can encourage various students with different learning styles to understand physics material well.

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The teaching materials are a source used by teachers to carry out pedagogical activities and can affect student learning outcomes [13]. The teaching materials have an important factor in improving High Order Thinking Skills (HOTS). Therefore, teaching materials need to be developed based on student needs. In addition, teaching materials are also an essential component in determining the quality of education [14].

The content of teaching materials is also one of the external factors that can affect the intensity of student understanding, so it needs to be optimized. Physics material that has many phenomena needs to be deepened in teaching materials, namely by integrating SETS (Science, Environment, Technology, and Society). SETS is a learning concept that can provide direct experience related to the scientific process to students. This experience is associated with the concept of technology work, the environment, and various phenomena in society, which are observable or observable. SETS-integrated learning is effective in connecting science events with various phenomena that occur in the environment, technology, and society, so that it can train students in thinking and increase their understanding [15]. Increased thinking ability and understanding will help improve student learning outcomes.

Critical thinking skills and understanding that are not optimized have the potential to make students less able to face various challenges in the 21st century, both in education and work in the future. Thus, it is necessary to research teaching materials that use the inquiry and SETS approach to physics material, so that it can be used as a benchmark for quality teaching materials in improving effective learning in the 21st century. This study aims to determine the effectiveness of SETS-integrated inquiry-based teaching materials on dynamic fluid subjects.

Research Method

This research uses a mixed method approach [16], so the data were analyzed qualitatively and quantitatively. The feasibility of teaching materials was tested by material experts and media experts. The results of the validation test by material and media experts will be analyzed by calculating the average value of each aspect using equation (1). The analysis results are interpreted based on Table 1.

$$PS = \frac{\sum S_i}{n}\ 100\ \% \tag{1}$$

Description:
PS = Score Percentage
$\sum S_i$ = Total score in i aspect
n = Total indicator in i aspect

Table 1. Interpretation of Expert Validation Results

Percentage (%)	Classification
81 – 100	Very Feasible
61 – 80	Feasible
41 – 60	Feasible Enough
21 - 40	Less Feasible
0 – 20	Not Feasible

The teaching materials were tested at SMA Negeri 2 Kisaran, North Sumatra Province, to determine the practicality of the product. The results of this test were then analyzed by

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calculating the average value of each indicator using equation (2). The results of the practicality test analysis will be interpreted based on Table 2.

$$PS = \frac{\sum S_k}{n}\ 100\ \% \quad (2)$$

Description:
PS = Score Percentage
$\sum S_k$ = Total score in k indicator
n = Total questions in k indicator

Table 2. Interpretation of Practicality Test Results

Percentage (%)	Clasification
86 – 100	Very Practical
76 – 85	Practical
60 – 75	Practical Enough
< 60	Not Practical

Teaching materials that have been declared valid and practical are then tested for product effectiveness. The sample used in this study amounted to 36 students, namely class XI MIPA 1 SMA Negeri 2 Kisaran. Students were directed to work on pre-test questions as many as 10 questions, with the questions used being valid questions. The module was then studied independently by all students in class XI MIPA 1. At the end of the activity, students were directed to work on post-test questions which were formative assessment questions on the module, to determine the level of product effectiveness.

In the effectiveness level test conducted through pre-test and post-test, the assessment system used is a complete assessment. Student learning achievement is seen based on the formative assessment scores that pass according to the Criteria for Achieving Learning Objectives CALO). CALO in the Merdeka Curriculum uses a range of values as listed in Table 3. Based on the results of the response test on the physics teacher, CALO is declared complete if students get a score of 75.

Table 3. Criteria for Achievement of Learning Objectives (CALO) [17]

Score	Description
81 – 100	Very Good
71 – 80	Good
61 – 70	Enough
0 – 60	Need Guidance

The data were analyzed using the N-gain equation [18]. The N-gain equation can be seen in equation 3.

$$\langle g \rangle = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

Description:
$\langle g \rangle$ = *N-gain* Score
S_{post} = *post-test* Score
S_{pre} = *pre-test* Score
S_{max} = Maximum Score

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The results of the N-gain calculation were interpreted based on the scoring effectiveness criteria in Table 4.

Table 4. *N-gain* Scoring Effectiveness Criteria [18]

***N-Gain* Score Interval (%)**	**Qualification**
71 – 100	High
31 – 70	Middle
0 – 30	Low

Results and Discussion

Results

Based on the results of research on inquiry-based teaching materials by integrating SETS, it was found that the teaching materials were declared valid by material experts with an average percentage of 83.85%. The results of validation by material experts can be seen in Table 5.

Table 5. Material Expert Validation Results

Assessment Aspect (Feasibility)	**Aspect Percentage (%)**
Content	83,70
Linguistics	82,30
Presentation	85,55

Based on the results of validation by media experts, it was found that the assessment of the teaching material media developed was valid, with an average percentage of 81.48%. Media validation results can be seen in Table 6.

Table 6. Media Expert Validation Results

Assessment Indicator	**Percentage Indicator (%)**
Size of teaching materials	80
Use of fonts	75
Layout	72
Illustrations and pictures	82
Display design of teaching materials	80

Based on the research conducted, the average pre-test score obtained by students was 35.83. Figure 1 shows the results of students' pre-test scores. The product implemented is a SETS-integrated inquiry-based module on dynamic fluid material.

The module is one type of teaching material that is intended to be used and studied independently by students. Therefore, in this study, the physics module was studied independently by students. In supporting the monitoring of the student learning process, the module is supported by Google form to see the development of sub-chapters that students have learned. However, obstacles were found during the independent learning process, namely, students were not motivated to study and work on formative assessments in the module. Therefore, the researcher conducted a direct review or control of the school to provide motivation and explain more deeply the benefits of independent learning using modules. Therefore, students were then motivated to study the module well.

The initial results of formative assessment work on the module obtained an average score of 90.28. 30 students scored above 75, with 21 students scoring 100, 5 students scoring 90, and 4 students scoring 80. However, 6 students still scored below 75 or had not passed the CALO, where 2 students scored 70, and 4 other students scored 60, so it was necessary to carry out

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learning stabilization. Students are then directed to do remedial until they get a complete score. Based on the results of remedial work carried out by the 6 students, it was found that as many as 4 students had passed CALO with a score of 80, 1 student passed CALO with a score of 90, and 1 student passed CALO with a score of 100. Thus, the average formative assessment score obtained was 93.89, with the lowest score being 80, while the highest score was 100.

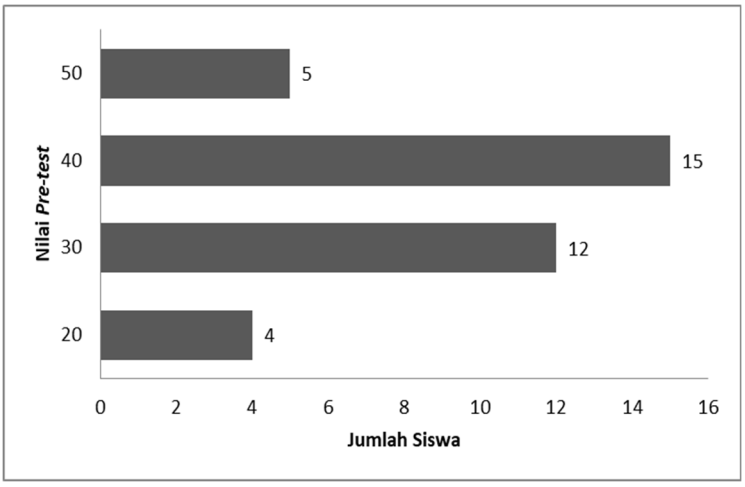

Figure 1. *Pre-test* Score

The formative assessment scores of students who had passed the CALO were used as students' post-test scores. This is because all students have met the criteria for complete learning. Based on the calculation of the N-gain test, the results were found as shown in Table 7 which shows the N-gain value with an average value of 0.90 (90.48%) and is declared to have high effectiveness. This indicates that the physics module made is effective in supporting the students' independent learning process on dynamic fluid subjects.

Table 7. *N-gain* Test Analysis Results

Description	Score	
	Pre-test	***Post-test***
Total Score	3.250	3.380
Average	90,28	93,89
N-gain Score	0,90	
N-gain Score (%)	90,48%	
N-gain Interpretation	High	

Discussions

The results showed that inquiry-based teaching materials integrated with SETS concepts can be used by students to support the teaching and learning process and achieve the outcomes of classroom learning. In the implementation of the study, students were given pre-test questions totaling 10 questions in the form of multiple choice. The questions given are valid, namely from the bank of questions from college entrance exams and national exams. Based on the pre-test results, it was found that all students still did not have a sufficient understanding of dynamic fluid material. The average pre-test score obtained by students is 35.83, with the lowest score of 20 for as many as 4 students, and the highest score of 50 for as many as 5 students. In addition,

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12 students scored 30, and 15 students scored 40.

The module innovation in digital form is one of the developments needed in the 21st century [19]. The 21st-century skills have encouraged educators to develop their abilities to meet the needs of learning reform [20]. Physics learning by optimizing the use of digital media can improve students' learning independence abilities. The world is facing the challenges of the 21st century with very tight competition for Human Resources (HR). The quality of human resources is influenced by the quality of education and based on the guidance of applicable norms [21]. The increase in skills needed in the 21st century will also encourage the optimization of various student competencies needed in various sectors in the future [22].

Thinking is a complex process, and is needed in physics learning [23]. The ability to think critically is one of the abilities that is needed to master a material. Critical thinking skills have long-term benefits, both in education and its application in everyday life [24]. Based on the results of research [25], inquiry-based learning has the potential to improve students' critical thinking skills, especially in the process of learning science, because students are encouraged to actively connect science concepts with their observations in nature. This is also in line with the results of research [26], which states that inquiry-based learning can increase students' motivation to think critically, thus increasing student engagement, understanding, and learning outcomes. Inquiry-based learning can improve students' investigative skills and science practices. The increase in these abilities is maximized because students are actively involved in finding solutions and conclusions from the questions that have been formulated [27].

After doing the pre-test questions, students studied the dynamic fluid subject by using the SETS integrated inquiry-based physics module independently and thoroughly. This is by the purpose of learning using the module, which is studied independently until completion. Student learning completeness is seen from the achievement of the CALO pass mark on the formative assessment, which is to obtain a minimum score of 75.

Based on the results of the study, the initial average value of the formative assessment that students did was 90.28. 30 students obtained a CALO pass mark, including 21 students able to obtain a score of 100, 5 students able to obtain a score of 90, and the remaining 4 students obtained a score of 80. However, 6 students have not passed CALO, namely with a score of 70 by 2 students, and a score of 60 by 4. Students who have not obtained a CALO pass mark of 75 do remedial until they get a CALO pass mark. Based on the remedial results, 4 students passed the CALO with a score of 80, 1 student managed to get a score of 90, and 1 student passed with a perfect score of 100. Therefore, the average score of students' formative assessment results became 93.89.

The formative assessment at the end of learning is part of the assessment of learning outcomes. The assessment of learning outcomes needs to be done to determine the level of student development and the effectiveness of learning implementation [28]. The formative assessment should be included at the end of learning as part of the learning evaluation process [29] and formative assessment is one of the most effective strategies to improve the quality of learning in schools [30].

One form of evaluation based on previous assessments and research is the creation of modules in this study which is based on the results of observations related to student learning outcomes on dynamic fluid material which is still not optimal. The formative assessment is a process of monitoring student learning outcomes and abilities. Therefore, there is still a possibility of development from the research that has been done to date, to optimize teaching

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materials, learning processes, and student learning outcomes [31].

Based on the results of the N-gain test analysis, it has been obtained that the average N-gain value of students is 0.9 or 90.48%. This value is categorized as having high effectiveness. Thus, it can be stated that the SETS integrated inquiry-based physics module on dynamic fluid material at the high school level is effective in improving student learning outcomes. The improvement of learning outcomes is based on the ability of students who are trained in critical thinking and problem-solving, supported by the deepening of various physics phenomena, thus helping students have a more significant understanding of dynamic fluid material. The application of inquiry learning is very suitable for improving the quality of contextual learning. In addition, the knowledge gained during the learning process has the potential to be remembered in the long term and can increase creativity, investigative ability, critical thinking, reflection, and various skills needed to face challenges in the 21st century [32].

Conclusions

Based on the results of the research and analysis that has been carried out, it can be concluded that teaching materials in the form of inquiry-based modules with SETS integration on dynamic fluid material are effective in supporting students' self-learning process, and can improve student learning outcomes on dynamic fluid material. This is based on the results of the pre-test and post-test, with the N-gain test results being 0.9 or 90.48%, and declared to have a high level of effectiveness. Modules that function to support the process of independent and complete learning are more optimal by utilizing the potential for the development of science and technology in the form of modules. The use of Heyzine optimizes the function and usefulness of the physics module so that the visualization of physics phenomena and their simulation can be learned by students optimally. Thus, this study shows that the module's inquiry base and SETS integration effectively help students improve their understanding of physics material, especially through optimizing the presentation of the steps of inquiry and physics phenomena. The inquiry-based and SETS integration in teaching materials can encourage significant improvement in critical thinking and problem-solving abilities in students.

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The development of ethnoscience in schools: a bibliometric analysis with a detailed future insight review

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Abstract. *The last decade has seen the development of learning patterns in the world, namely with the emergence of various models, approaches, and strategies in learning. One of the most popular learning approaches is ethnoscience-based learning. The purpose of this research is to see and explore the development trends of ethnoscience-based research through bibliometric analysis and contributions to science education for the implementation of learning from various scientific articles sourced from the Mendeley database consisting of journals, Conference Proceedings, and books to get the distribution and relationship between research and authors and seen based on the year of publication and the source of publication and the distribution of publications on ethnoscience. This is because the learning process using the ethnoscience approach is very relevant to the current conditions of the Indonesian nation which is also adopted from various regions in the world. The variety of cultures, ethnicities, and tribes that exist in Indonesia has made the development of this research so fast, not only in Indonesia but also in several countries in the world. Based on the results and discussion, it can be concluded that the development of ethnoscience-based research on science learning in 2018-2023 contained in the Mendeley database, can be seen from the distribution of authors dominated by authors from Indonesia.*

Keywords: ethnoscience; bibliometric study, research trends

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Introduction

Indonesia is a country with many diverse islands, languages, cultures, and socio-cultural communities. With 38 provinces spread evenly in the equatorial region, it produces many cultures and ethnic diversity. This becomes one part of the educational approach where learning by adopting local culture becomes a new trend in learning. In the last decade, learning with an approach to local wisdom has become a new trend in learning [1]. The occurrence of learning patterns that are called ethnoscience or ethnoscience has the meaning of a science that is owned by a nation or tribe. [2] [3] define ethnoscience as a set of understandings in the scientific field that are authentically characterized by a particular community, tribe, race, or nation. In the process of obtaining knowledge or science through the system or holistic norms that run in empirical knowledge that has been tested and accounted for by the community through testing by hereditary experience. Ethnoscience has different definitions according to the opinions of experts as researchers with a focus on the cultural context as adjusting the culture seen from the side of a person's residence and applying it in every aspect of daily life. Local wisdom is one of the approaches in society to achieve educational goals and conditions where students carry out PBM (Teaching and Learning Process) so that it makes it easier for students to understand learning concepts [4] [5].

In addition, there are 3 fields of ethnoscience research studies in local wisdom-based learning research. Of the 3 research focuses, among others 1) An ethnoscience approach that focuses on the culture of the social atmosphere experienced. In the social life of the community. This research process shows how the norms that exist in society with empirical studies to organize between the symptoms that appear in the field with the knowledge possessed by the community group. 2) An ethnoscience approach that focuses on research in saying the culture found in citizens in the form of norms, the order of bad or good community life, and the level of knowledge development and technological concepts. 3) An ethnoscience approach that focuses on the culture of a community group as a phenomenon that can form a community of people gathered and behaviorally influence attitudes at any time. The 3rd research study is the analysis of habits often used as research study material in citizens who indirectly carry out science activities [6].

Local wisdom in a community usually describes a phenomenon that is typical of a particular ethnicity in a region or community group by educators in the education process. Some of the uses of local wisdom in today's global time measure [7].

Understanding of natural conditions or often called science in the community environment is understood and measured in the form of symbols or translated in the form of cultural messages, customs, and religious ceremonies which contain science-based social norms owned by the community, from generation to generation to become a reference for certain communities or social groups even though it has not been officially tested through massive knowledge methods. [8]. The original exact science knowledge is a set of knowledge, in the form of messages, symbols, customs, and social culture covering the fields of natural sciences, physics, earth and space, biology, agriculture, chemistry, life sciences and so on that have scientific principles and concepts [9][10] unofficial science.

Ethnoscience-based research is currently only concerned with cultural approaches that are linked to partial parts of education and have not looked at mapping the impact and trends in the world of education. In addition, science teaching and learning is officially taught in a unit of

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study commonly known as a school or large academy. Original science knowledge [11] is scientific knowledge that is not yet official. In addition, mapping and research trends are not clearly illustrated, making it difficult for other researchers to see the potential and novelty of ethnoscience-based science education research. The development of the number of articles is also not clearly visible to researchers and the distribution of research carried out.

In this case, the science approach by collaborating with local norms and wisdom makes education more colorful, where the exact science materials taught are not only focused on results with the usual dialogue used in the science approach. Therefore, the natural science approach with local wisdom conditions makes learning at the education unit level has great meaning. Learners are not only faced with numbers [12] Therefore, research with this approach is quite developed in parts of the world because it tries to bring the cultural context of the region closer to knowledge. However, there is no research that looks at the distribution of existing ethnosciences-based research patterns with the database of the application that holds various scientific articles in the Mendeley application so accurate data are needed to look at this problem more deeply.

Through the concept of the study of Natural Sciences, students will be more in-depth in the learning process de facto real conditions in the field, and in addition students are also able to carry out implementation to further deepen the learning experience that has been followed thoroughly in everyday life [13]. In this case, ethnoscience-based learning is very relevant in Indonesia because the geography and content are full of cultural approaches and community norms that have long existed and developed in Indonesia and in other parts of the world. Therefore, qualified research and analysis are needed to be able to see how far the learning potential is [10][13] based on culture and local wisdom in various countries around the world and in several regions and provinces in Indonesia in detail and focus on analyzing its development through existing research and scientific writings. From the data on the results of research and existing writings, it will be seen here that the distribution of the use of the ethnoscience approach is a reference in the implementation of education, as well as for mapping in conducting research in various countries and in Indonesia in particular. So that educators and researchers who oversee the problem can take an overview or reference to the analysis that has been presented.

Method

In this study, the method designed in the systematic analysis of this research is a descriptive bibliometric analysis using a publication database on the topic of information ethnoscience in the range of 2018 - 2022 with the limitation of four sources of study fields including sources from Journals, Conference Proceedings, Book Section, and Book and restrictions in the form of a total of 435 documents and a duplication test was carried out to produce 418 articles, this was done with the aim of narrowing the search for ethnoscience-based learning approaches. Data collection is done through searching indexed publications in the Mendeley application imported into Mendeley Desktop. This article review method uses bibliometric visualization analysis. This method aims to provide a structural overview of a particular topic [14]. The research subjects were 283 articles indexed in Scopus, Web of Science, on the topic of ethnoscience approach in science learning. This publication is in the range of 2018- 2022. The stages of bibliometric analysis carried out are searching for journal article data

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through the Mendeley application, checking article completeness, mapping articles, conducting bibliometric analysis with Vosviewer, and making conclusions [15].

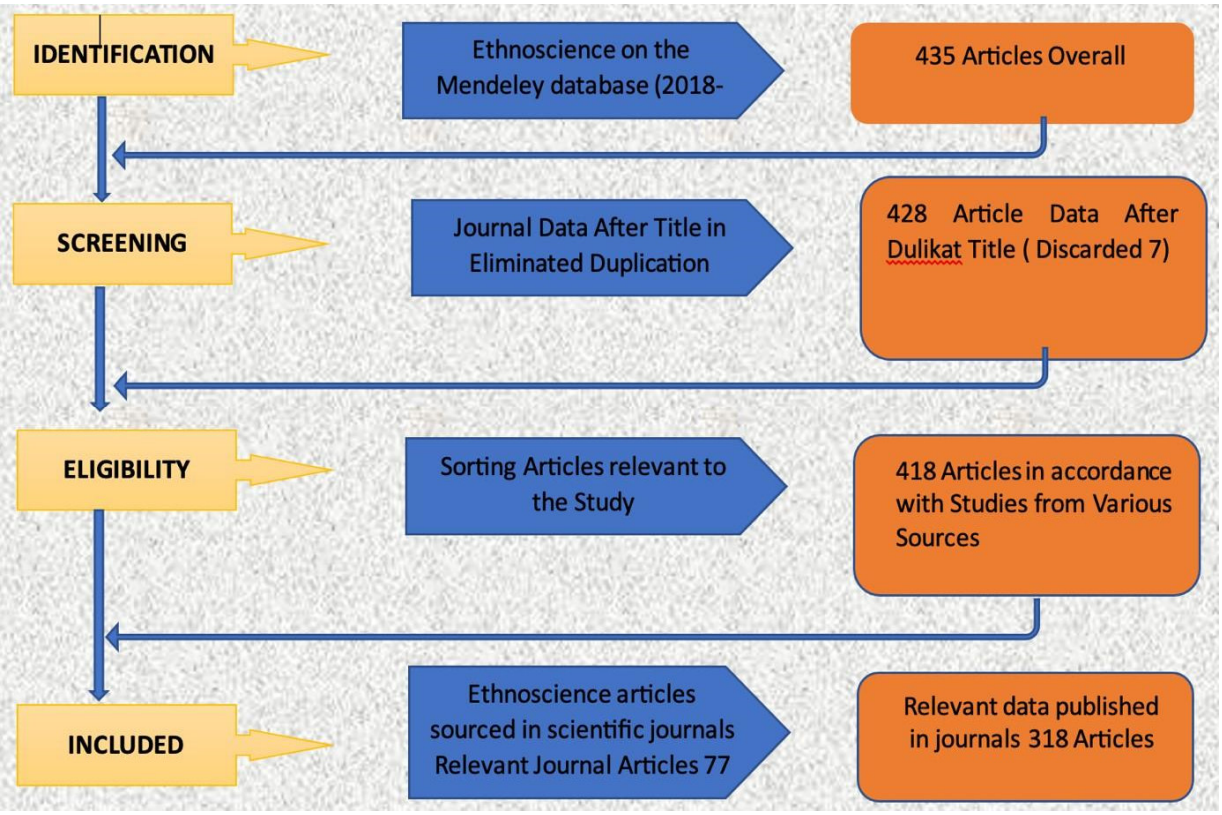

Figure. 1. Flowchart of Article Selection

The search keywords used the words "Ethnoscience" and "Education" in the Mendeley application. After that, sorting and checking of articles that meet the requirements, namely publications at least in 2018, from reputable journals indexed by Scopus, WoS, or other reputable publishers. For bibliometric visualization using the VoSviewer application. mapping various types of bibliometric analysis; [15] by taking several scientific article writings from the data provider platform with Primary bibliographic data, for the time dimension divided into categories for 5 years of articles that have been published, by analyzing small, and medium and large data. Furthermore, the data is viewed from the title and the summary in the abstract by performing output techniques and data clustering. To adjust to the advanced visualization features by using the overlay visualization model and viewed in terms of density.

After the data is obtained and stored in the form of a RIS file or Research Information Systems Citation File, the next step is to enter the file into the Vosviewer software with the aim of visualizing network patterns or relationships between bibliometrics, [16] into three categories, including the network visualization process, besides that, it also uses Overlay visualization, and

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the last one uses modeling with density visualization. Network visualization aims to visualize the strength or not of the network or relationship between terms (terms) of research, overlay visualization aims to visualize historical traces based on the year of publication of research, while density visualization aims to display the density or emphasis on research groups.

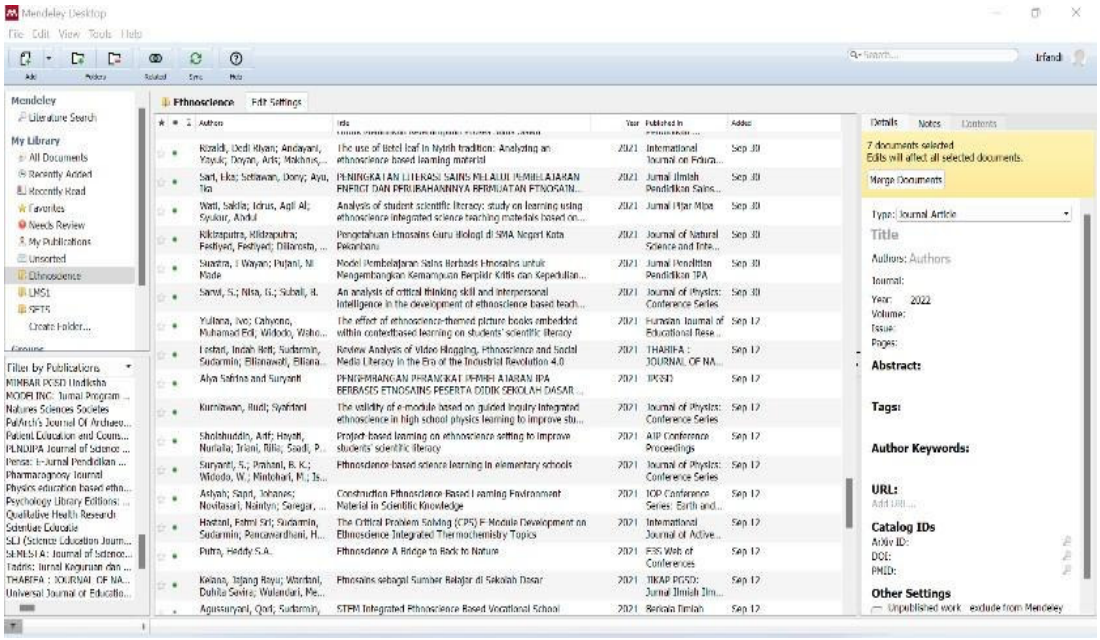

Figure. 2. Search method through Mendeley Desktop Source: Mendeley Desktop (2022)

The research method of analysis with the bibliometric process is an application using statistical and mathematical methods by projecting with a literature base such as scientific journal articles, conference proceedings, books, magazines, and online publications, and using a variety of varied communication tools. [17][18]. The mapping obtained by Vosviewer can later be used as a reference in conducting accurate content analysis based on the researcher's name, publication year, researcher productivity, and information architecture research trends. In this study, bibliometric analysis was conducted to analyze the collaboration of authors in information architecture research and analyze bibliometric relationships based on keywords (co-occurrence). After the data is mapped, it is then analyzed by reviewing selected reputable journals in accordance with ethnoscience-based education in reputable journals.

Results and Discussion

Based on the database contained in the Mendeley citation application with the keyword "ethnoscience", there are 2418 documents found related to ethnoscience-based learning research, with data taken for 5 years in the period 2018-2022. The graph of the development of ethnoscience research publications shows a positive trend, namely a significant increase. Where we see data in 2018 there are 47 articles entered in the Mendeley database or around 11.24% of the total.

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Furthermore, in 2019 there was a significant increase in the number of presentations where the number of articles rose to 15.07% or increased when compared to the previous year, which was 63 research articles dominated by journals and proceedings.

Table 1. Development of Ethnoscience publications on the Mendeley Application (Source: Personal Data Processing Results (2023)

No.	Year of Publication	Number of Articles	Percentage
1	2018	47	11.24%
2	2019	63	15.07%
3	2020	96	22.97%
4	2021	117	27.99%
5	2022	95	22.73%
	Total	418	100 %

And the following year 2020 experienced a very rapid increase, namely the number touched 96 articles or increased by more than 10% from the previous year to 22.97% of the existing data. And the peak in 2021 was a fantastic increase where articles cited in the Mendeley application reached 117 articles or increased to 27.99%, this is a pretty good year for the development of ethnoscience-based research.

Figure 3. Development graph of Mendeley indexed Ethnoscience Approach publications Source: Personal Data Processing Results (2023)

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However, if we examine more specifically, we can see the data from the graphical image of the development of the publication of the Ethnoscience Approach indexed by Mendeley over a period of 5 years, in 2022 the number of publications has decreased significantly, touching 95 articles and documents cited by Mendeley. And the amount is quite distant from the number of studies from previous years, which is only around 22.73%. This raises the big question of why the research trend has gone down and seems to be less desirable or a decline in trends. However, this is an initial conclusion, because technically in 2022 there are still articles that have not been included in the data from the Mendeley database, besides that, citations in the Mendeley application usually take time, so journal and proceedings research articles usually take time to be cited by the Mendeley application [15].

And what is interesting is that if we disaggregate the data with the source of articles only in journals as a source, it turns out that every year there is an increase. In 2018 there were 33 journal articles, in 2019 there were 44 articles, in 2020 there were 68 articles, in 2021 there were 86 articles and in 2022 there was an increase of 87 articles. This means that many authors publish their articles in existing journals. So, in other words, the research products made by researchers are poured into articles in journals so not in the form of books, proceedings, reports, or others. In addition, if we observe and analyze the data in the Mendeley data source, most of the articles come from journals.

Both reputable international journals have Scopus, WoS and Thompson Reuters indexation. In addition, there are also quite a lot of nationally accredited journals that are used as sources so that the data obtained from 418 article titles, 73.10% or as many as 318 data sources come from various existing journal articles.

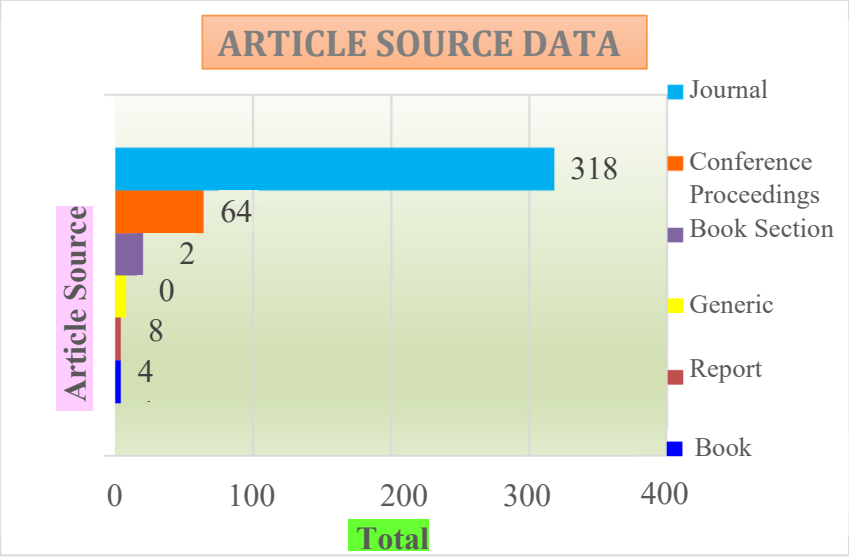

Figure. 4. Graph Ethnoscience approach article source

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Although dominated by journals, another source, which has a large enough number as a source of data analyzed is sourced from Conference Proceedings with the number of articles almost 1/6 of the total or 15.31%. When converted into a total of 64 Conference Proceedings articles, most of which are indexed by reputable indexing institutions, but in 2022 articles related to ethnoscience appear to be published less in Conference Proceedings and more in journals, because journals are considered more credible because they go through a complex review process [19]. Then followed by the book section and Book section which amounted to 20 titles of writings, as well as writings in general that were widely used as references as many as 8 writings, and 2 sources that were also considered relevant in retrieving the data, namely Reports and books of 4 titles each.

Discussion

VOSviewer-assisted Visualization of Ethnoscience Research Trends

From the bibliometric picture of VOSviewer Visualization Software, the mapping of ethnoscience-based research trends in science learning is assisted by VOSviewer software using a database from the Mendeley citation application from 418 documents related to ethnoscience-based research in science learning in 2018-2022. Based on visualization, several parameters, or interrelationships between subjects on ethnoscience-based research variables in science learning were found, such as the relationship between problem-based learning and research with ethnoscience [20].

In addition, the distribution in the figure above also shows an overall picture or map of the development of research on ethnoscience-based research on science learning in 2018-2022. In the visualization, it is known that ethnoscience-based research on science learning, in the world indexed in the Mendeley data base, has produced 3 clusters which are a large part of each topic, 5122 links, and a total link strength of 21,927. The three dominant color clusters are Red, Green, and Blue.

Based on Figure 5, it is known that the Red Primary cluster is a classification of subjects based on the problem being analyzed, namely regarding culture-based science research in Indonesia such as Science, knowledge, Concept, community, Culture, Indonesia, and concept. All the word items that appear are related to culture and science and ethnoscience in learning. This is reinforced by the presence of subjects, namely researchers and approaches where ethnoscience-based research is usually based on problems in society that use a cultural approach with the wisdom of science.

Whereas the green cluster is the classification of ethnoscience-based learning development subjects in educational institutions, namely schools [21]. This can be proven by the existence of the subject question, critical thinking skill, student response, student worksheet, and learning process. Where suitability is very familiar in the field of education [22], this is in line with the research carried out to find the relationship of articles between and ethnoscience research based on science learning.

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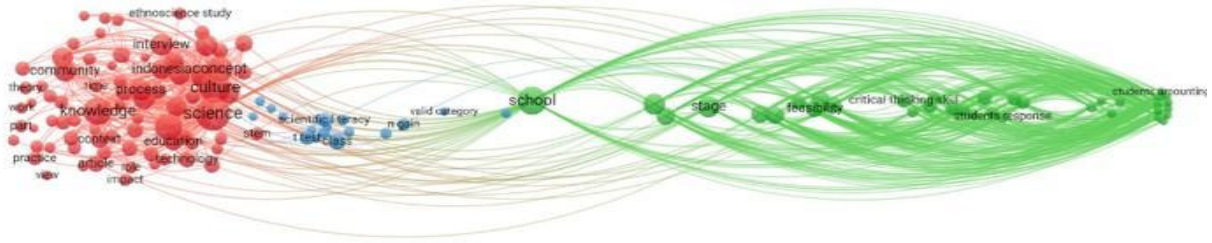

Figure 5. Visualization of VOSviewer Map of the development of Ethnoscience Publications in 2018-2022 in the Mendeley database.

In the Blue cluster, this classification is still related to the process, approach, community, and instrument. From here it is clear that the analysis carried out is closely related to ethnoscience with class, class control, scientific literacy, pretest, posttest, creativity, and innovation. not only at the level of higher education but also at the level of secondary level education can also be clearly seen directly. This argument is strengthened by the discovery of implementation subjects and students [23] where ethnoscience based learning is quite widely applied in the world of education both at the basic level of education and education at higher institutions [24].

From each of the existing primary clusters, we can sort out the dominant part, such as in cluster 1 or the colored red cluster, the dominant part is Science.

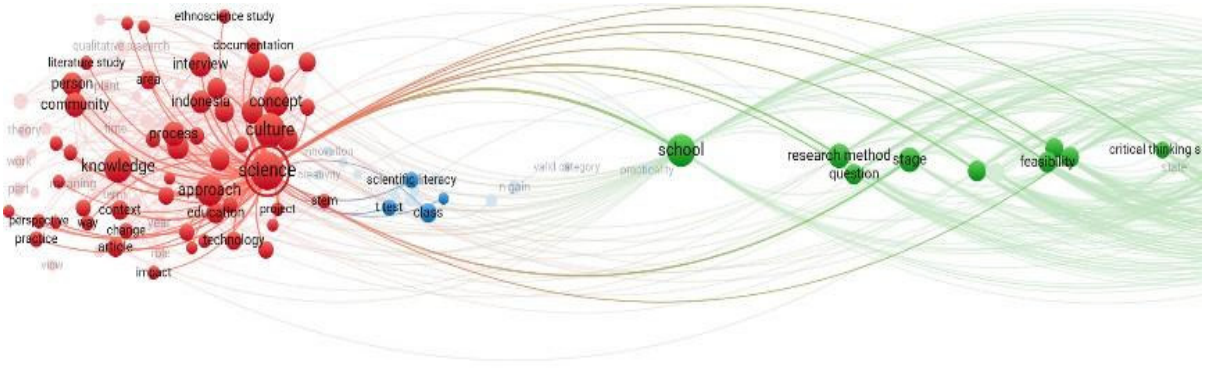

Figure 6. Visualization of Science Linkages with several variables

From Figure 6, we can see the novelty of the relationship between science and several variables studied, including science with culture, understanding or knowledge, and with the existing community or society. In addition, there are also relationships between clusters including science with schools, performances, and science literacy. The trend of science research is closely related to culture and society as well as educational institutions.

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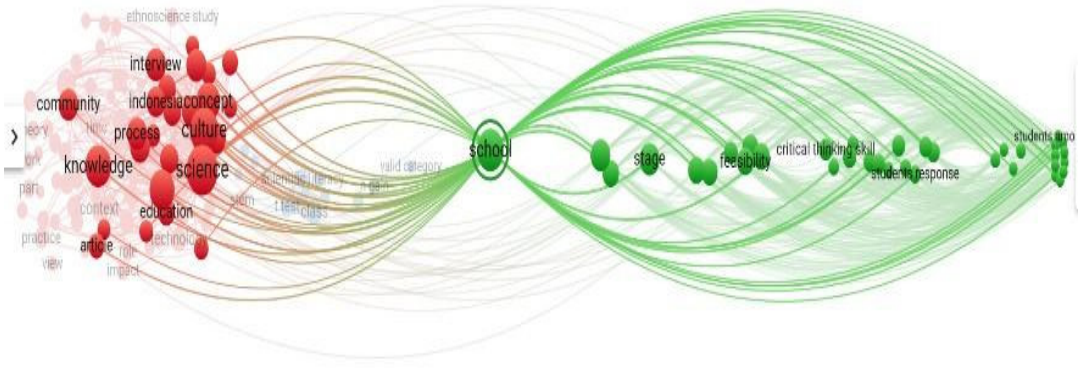

Figure 7. Visualization of school linkage with several variables [i]

Furthermore, in Figure 7, we can see that schools or educational institutions are part of the connecting link between the red and blue clusters and schools enter the blue cluster, so from 2018 to 2022 ethnoscience research in educational institutions occupies a positive trend, it can be seen that schools have links with research themes that are closely related to science, knowledge, science learning, ethnoscience study in the science and culture cluster. In addition, in the green cluster, there are some strong links from research trends that still overlap with education, namely implementation, critical thinking and student worksheets and no less strong appears the renewal of the relationship between ethnoscience research in schools with the learning process and student learning responses.

From Figure. 8 shows a visualization that illustrates the country that appears most in each study is Indonesia. This shows the interest in culture-based research in this country.

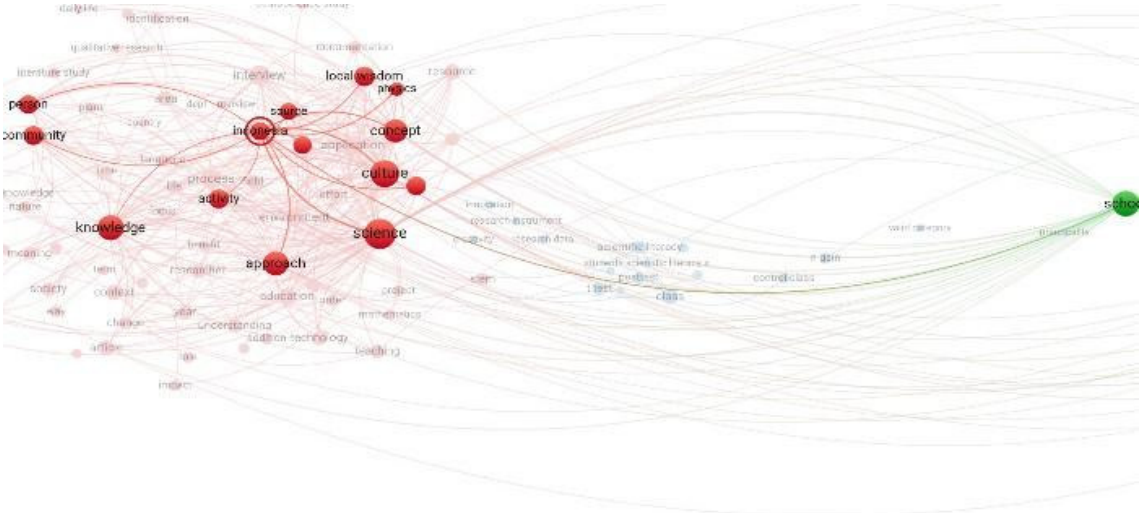

Figure 8. Visualization of the Relationship Between the Most Research Countries on Ethnoscience in Education

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This is not a strange thing because as an archipelago that has thousands of islands, and a variety of cultures ethnoscience-based learning is very relevant to conditions in Indonesia. From the description, we can see that the links with strong relationships in Indonesian research appear to tend to be about science, local wisdom culture, knowledge, approach, community, concept, and ethnoscience Approach. So, the closest relationship between ethnoscience-based research is implementing learning with an ethnoscience approach.

And the most unique thing is that ethnoscience research in Indonesia is closely related to the green cluster, namely schools. A lot of research is done in schools. And research on ethnoscience learning that is developing in Indonesia is still lacking to be developed but has emerged quite well is ethnophysics, it is still possible to do a deeper study on research in Indonesia.

After that in mid-2020 there was a little renewal in the dominant research, namely about the application of technology, culture, community, and critical thinking skills, this is in mid-2020 there was a change in learning patterns related to the impact of Covid-19 so that technology-based learning appeared in mid-2020.

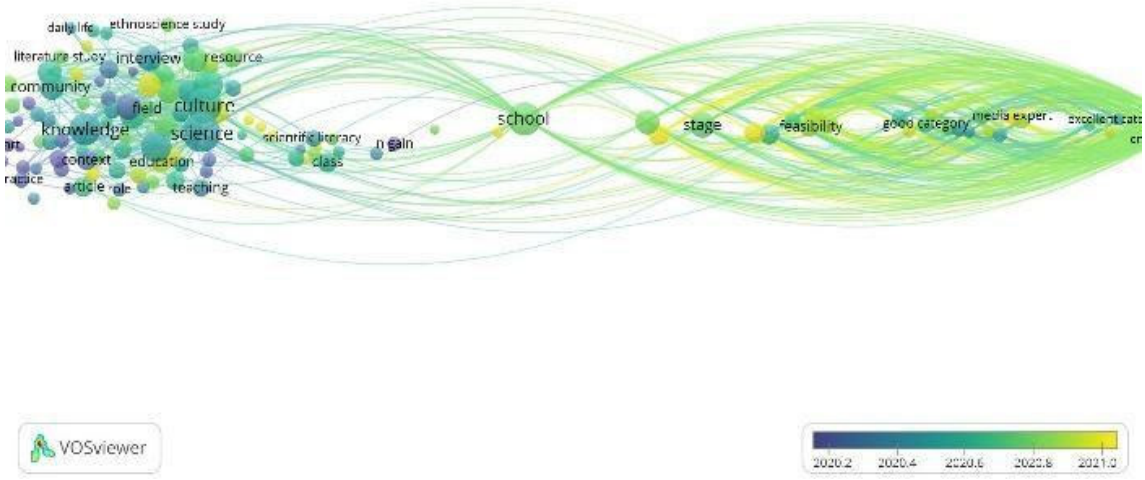

Figure 9. Visualization of ethnoscience development in 2020-2021

From Figure 9. We can see the distribution of research related to ethnoscience in early 2020, the distribution of research and writing revolves around the relationship between project-based learning, practice, and the learning process. This is also because in early 2020 a new curriculum was launched in Indonesia with project-based learning and contextualized practices with a science and culture approach.

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And in 2021 there was a significant development where this research was carried out in Indonesia and began to spread evenly in various regions so that this research was dominated by articles born in Indonesia. Research themes on education, science learning, and the Indonesian state and regional cultures are also quite dominant in research material. So many themes of novelty emerge from the unique cultures that exist in each region. This is also in line with the pattern of researchers about ethnoscience in the world all shifting to writers in Indonesia.

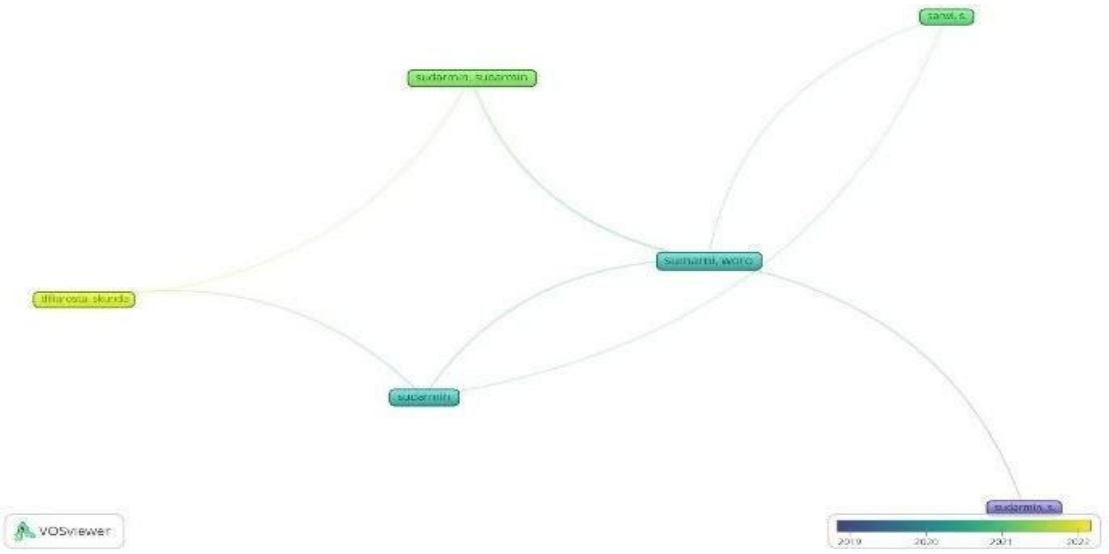

Figure 10. Visualization of Article Linkages with Predominantly Indonesian Authors

If we look at Figure 10, we will see several dominant names that focus on this research, including Sudarmin with several slightly different initials, namely Sudarmin S, Sudarmin Sudarmin and Sudarmin. In addition, Woro Sumarni, who appeared dominantly in mid-2020, and Sarwi, whose work was also widely published and used as a reference in 2021 [25-29], the most recent was a researcher and writer from Sumatra from West Sumatra who appeared dominantly in 2022. Between each author, there is a connection between each writing between each author so that the pattern is interconnected.

Conclusion

Based on the results and discussion, it can be concluded that the development of ethnoscience-based research on science learning in 2018-2022 contained in the Mendeley database has the highest number in 2021 which reached 117 articles or 27.99% of the total number of sources analyzed. The type of publication document that dominates the data source is in journals amounting to 76.08% or as many as 318 data sources from various existing journals. Although dominated by journals, another source, which has a large enough number as a source of data analyzed is sourced from Conference Proceedings with the number of articles almost 1/6 of the

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total or 15.31%. Although various sources of ethnoscience writing have decreased, the interesting findings from 2018 -2022, articles sourced from journals have increased with a positive trend.

Based on bibliographic data, some mapping of novelty arises from the existing source articles, there are 3 clusters that appear first about science and culture in Indonesia then the second cluster about the development of learning in educational institutions or schools, and the third cluster is about variable tests, creativity, and innovation. An interesting finding is that in scientific research there is a strong relationship between science and several variables studied, including science with culture and education, understanding or knowledge, and with existing communities or societies.

In addition, there are also relationships between clusters such as science and schools, performances, and science literacy. Ethnoscience articles in the last 5 years are dominated by articles and research from Indonesia, which dominates many of these writings related to science education. As well as popular writers from Indonesia and the most surprising in 2022 appeared writers from West Sumatra who were enlivened by ethnoscience articles. Between one author and another author has a strong and interconnected relationship in ethnoscience research. (Hadi* et al., 2020).

Acknowledgments

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Validity of digital learning media for information technology and data literacy courses to optimize hybrid learning in the physics department

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Abstract. *As part of the post-Covid-19 normalization of learning at Medan State University, hybrid learning is expected to remain an option. Learning flexibility in blended learning has proven to be an effective transition from fully online learning to blended learning and fully traditional/offline learning. To support blended learning, students' digital skills need to be improved to achieve optimal learning outcomes. Therefore, the learning quality of information technology and data literacy courses, which are compulsory courses for teachers, needs to be further improved as they are the basis for students to attend lectures in the Physics Department of Medan State University. To optimize blended learning, this study aims to design and develop LMS-based interactive digital media to optimize teaching materials for blended lectures on information technology and data literacy courses for physics students. The study*

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adopted the ADDIE development research method, which consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. The digital media produced was validated by material experts and media experts. The results of the instrument were analyzed quantitatively and descriptively. The average result of the material expert's validation assessment of teaching materials for all indicators was 81.74% or in the highly valid response category and the media expert's average assessment was 88.4% or in the highly valid response category. These results indicate that the digital learning media product had fulfilled the validity test based on the validator's assessment.

Keywords : digital learning media, hybrid learning, ADDIE, validity

INTRODUCTION

Learning in Indonesia is entering a transitional period from learning that accommodates the COVID-19 pandemic health protocol to new normal era learning since the revocation of PPKM status as stated in the Minister of Home Affairs Instruction Number 50 and 51 of 2022. This marks a new chapter of learning in Indonesia after the COVID-19 Pandemic with no more restrictions on crowds and community movement. The learning process from elementary school to university level can gradually change the learning pattern from hybrid learning to full face-to-face learning.

The same impact will also be felt in academic activities at Universitas Negeri Medan. Referring to the last circular letter during the pandemic lectures, namely the Chancellor's Circular Letter concerning Guidelines for Academic Activities for the Even Semester 2021/2022, blended learning is an option there, with a percentage of offline and online learning according to certain needs and conditions. This condition is essentially not much different if blended learning is implemented again, as in normal conditions before the COVID-19 pandemic hit in 2019. Blended learning will be the main choice in the future [1], as well as in Universitas Negeri Medan.

Blended learning is a combination of face-to-face learning in the classroom and online learning using a particular platform [2][3][4]. Contrary to full online learning, blended learning allows materials, students, and teachers to interact even though they are in different spaces [5]. When the application of blended learning In line with the development of sophisticated internet networks, this has led to a revolution that allows learning to occur "anytime and anywhere" online around the world [6].

As one of the determining factors for the success of blended learning, the competence of lecturers and students in utilizing and managing the online learning process must be continuously improved [7]. The ability to understand and utilize information in various forms and sources that are widely accessible through computers is also one of the supporters of the success of online learning. More specifically, this competency is known as digital literacy [8].

However, in reality, the digital literacy skills of students majoring in physics at Medan State University are still relatively low. From the data on the results of the plagiarism detection examination of the theses of students majoring in physics in 2021. The initial examination of student theses showed 85% plagiarism detection results with an average score above 50% of the total application submission [9]. Furthermore, in the 2022 student plagiarism check in the physics department, 43% of student theses with plagiarism scores above 50%. This result shows the low ability of students in the ability to adapt information which is an important element in digital literacy. This phenomenon also shows the tendency of students not to show literacy ethics

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in collecting and utilizing information from various sources. Copy and paste activities are still a common thing for students who need to review and paraphrase the information obtained.

One of the efforts has been made by developing electronic teaching materials for information technology and data literacy courses in 2022 research. From the validator's input regarding teaching materials, the teaching materials developed are good, but it is necessary to add more interactive media to maximize the message to be conveyed. In line with this, the results of student responses are in a good category, with similar suggestions, namely the addition of more interactive media so that students can be more enthusiastic in lectures. In addition to teaching materials, supporting learning media is also needed so that learning becomes more optimal. Therefore, the design and development of interactive digital media is an urgent need.

Based on the description above, development research was conducted to design and develop LMS-based interactive digital media that can be used to support learning in information technology and data literacy courses. The results of this study are expected to help improve the quality of learning and become a reference for implementing learning.

Methodology

This type of research is research and development, with the final product of digital learning media for Information Technology and Data Literacy courses, using the ADDIE model. The development stage consists of five stages, namely analysis, design, development, implementation, and evaluation. The digital learning media underwent a validation process by both material experts and media experts. The responses from the validators were gathered utilizing a Likert scale ranging from 1 to 5 [10]. Subsequently, the total score was divided by the highest achievable score. The findings were then assessed for the suitability of the developed learning materials, following the evaluation criteria as outlined by Sugiyono [11].

Result and Discussion

To assess the feasibility of the information technology and data literacy learning materials that have been developed, the digital learning media are first subjected to validation by material and media experts. This validation process involves evaluating the functionality, reliability, usability, and efficiency aspects of the media. The outcomes of this material expert validation are presented in Table 1.

Table 1. The validity of digital learning media

Indicator	Response Percentage	Criteria
Functionality	81.00	Highly Valid
Reliability	83.33	Highly Valid
Usability	80.00	Valid
Efficiency	85.00	Highly Valid
Average	**81.74**	**Highly Valid**

The results in the table above show that the digital learning media produced is very effective as assessed by material and media experts. The media effectiveness aspect is the aspect with the highest assessment with a percentage of 85%. While the usability aspect had the lowest result with a percentage assessment of 80%. The low usability aspect is the validator's concern because the use of the LMS is limited to only being used by Medan State University students.

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Furthermore, the validator suggested increasing access to use by making the LMS publicly accessible. The results of each validator's assessment can be seen in Figure 1 below.

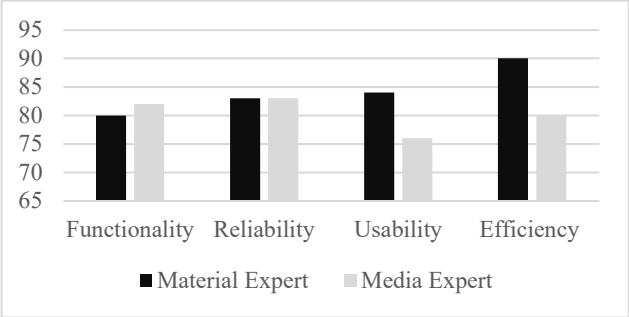

Figure 1. Material and Media Expert Validation Result

Conclusions

Digital learning media designed for information technology and data literacy have been made feasible through a validation process by materials and media experts. After verification by materials and media experts, it was concluded that the developed teaching materials had very effective aspects. This conclusion means that the developed teaching materials can enter the open testing phase of the next research phase.

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Smart Module for General Physics Practicum Based on the Case Method and Team-Based Project

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Abstract. *After the COVID-19 pandemic, many people are still adopting off-line practicum systems, one of which is via video, even though a good practicum should allow students to be able to carry out experiments directly. The research aims to determine the effectiveness and practicality of the Smart Module for Practicum in General Physics courses. The type of research is R&D with the 4-D development model proposed by Thiagarajan and Semmel. Data collection techniques include assessment instruments, material validation questionnaires, media validation questionnaires, question validation questionnaires, and student response questionnaires. Based on the research results, it was concluded that the smart module for general physics practicum guidance is valid and ready to be used*

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in practicums. Based on the results of student responses, it was concluded that the Smart General Physics Practicum Guide Module was very practical and effective for use in practicums.

Keywords : Smart Module, General Physics Practicum, Case Method, Team-Based Project

Introduction

Practical activities are student activities that play an important role as a means of cultivating thinking skills to analyze data obtained from observations [1], [2]. Practical activities are important in learning, especially science because students can prove themselves or discover for themselves the concepts of the material being studied through practicums so that students become more aware of the concepts of the material [3]. It was concluded that science, especially Physics, is very closely related to Practicum because to make it easier for students to understand concepts, they must be able to prove phenomena or concepts themselves by directly researching and analyzing data as well as improving students' thinking abilities.

The General Physics course has special Practicum hours in the Physics Department, at Medan State University, but the problem is that it does not have a standard practicum guide, meaning that each lecturer in the General Physics course has the freedom to develop a practicum guide. Another obstacle is that during the COVID-19 pandemic, the practicum activities carried out were using practicum videos on YouTube for students to analyze themselves, even after the pandemic there were still some who used practicum videos on YouTube as practicum activities.

Based on the problems found, a standardized practicum guide is needed, meaning it can be used offline and online while adapting to students' learning styles. The solution offered is the Smart Module, Smart Module, General Physics Practicum Based on Case Method, and Team-Based Project. The reason it is said to be a Smart Practicum Module is because the guide that is produced can be adapted to the student's learning style. Learning style is a person's way of receiving information using different levels of focus to get optimal learning results [4], [5]. For example, if the student's learning style is Reading/Writing, it has been provided in the reading/text module which can be used to more easily understand the practicum, as well as the audiovisual learning style which can use videos to understand the practicum.

The advantage of the Smart Module that was developed, apart from adapting to student learning styles, is that it plays a role in improving thinking skills because it is based on the Case Method and Team-Based Project. The case method is a participatory discussion-based learning method for solving problem cases that helps students hone and improve critical thinking skills to solve a problem and can hone critical thinking skills for case solving, communication, collaboration, and student creativity [6]–[8].

Team Based Project is a form of student-centered learning, aimed at developing more independence in students. The most important thing in the independent learning process is increasing students' abilities and skills in the learning process without the help of other people so that in the end students do not depend on lecturers, supervisors friends, or other people in learning. When students experience difficulties, they will ask questions or discuss them with

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friends, lecturers, or other people. Independent students will be able to find the learning resources they need [9], [10].

Method

The development model that will be used in this research is the 4-D development model by Thiagarajan and Semmel in 1974 [11] with the stages of implementation consisting of Define, Design, Development, and Dissemination [12]. The data collection technique used in this study was an assessment instrument with a questionnaire. There will be 4 questionnaire assessment instruments, namely material validation questionnaires, media validation questionnaires, question validation questionnaires, and student response questionnaires. The questionnaire grid was developed based on the formative evaluation instrument for teaching materials published by the Ministry of National Education in 2008.

Data analysis techniques are carried out to obtain good quality products that meet the aspects of validity, practicality, and effectiveness. Data were obtained through expert validation, student response questionnaires, and tests for the effectiveness of learning with practicum guidelines**.**

Result And Discussion

Based on the 4D development model, the Define stage begins, namely initial-finish problem analysis, student analysis, and material analysis. At the beginning-to-end problem analysis stage, it was found from observations by taking a sample of the PSPF 22B class that only 23% of the General Physics UTS scores passed without remedial. In the student analysis, it was found that understanding of physics concepts was still low due to low student interest in physics courses, and the average student said they were not interested due to lack of student interest, and practicums were carried out online (via Learning Management System). In the material analysis, it was observed that the material applied was the practical material in the RPS.

After completing the Define stage, then enter the second stage, namely Design. The activities carried out at the design stage are the development of ideas in determining the objects used in the smart module. Furthermore, concept analysis focuses on the procedural skills of digital-based teaching materials and concept analysis focuses more on the process of compiling materials based on the RPS of general physics courses. The activity continues by making a storyboard to make it easier to visualize the main points of the display so that they are more organized.

The third stage in 4D is Development, at the development stage we have started to create a smart module using the hayzine.com application which is guided by the storyboard. After completing the creation of the smart module, the module will be tested for feasibility by validating it with several experts. The first stage of validation is the Media expert who produces very good qualifications. The media expert validation results can be seen in Figure 1.

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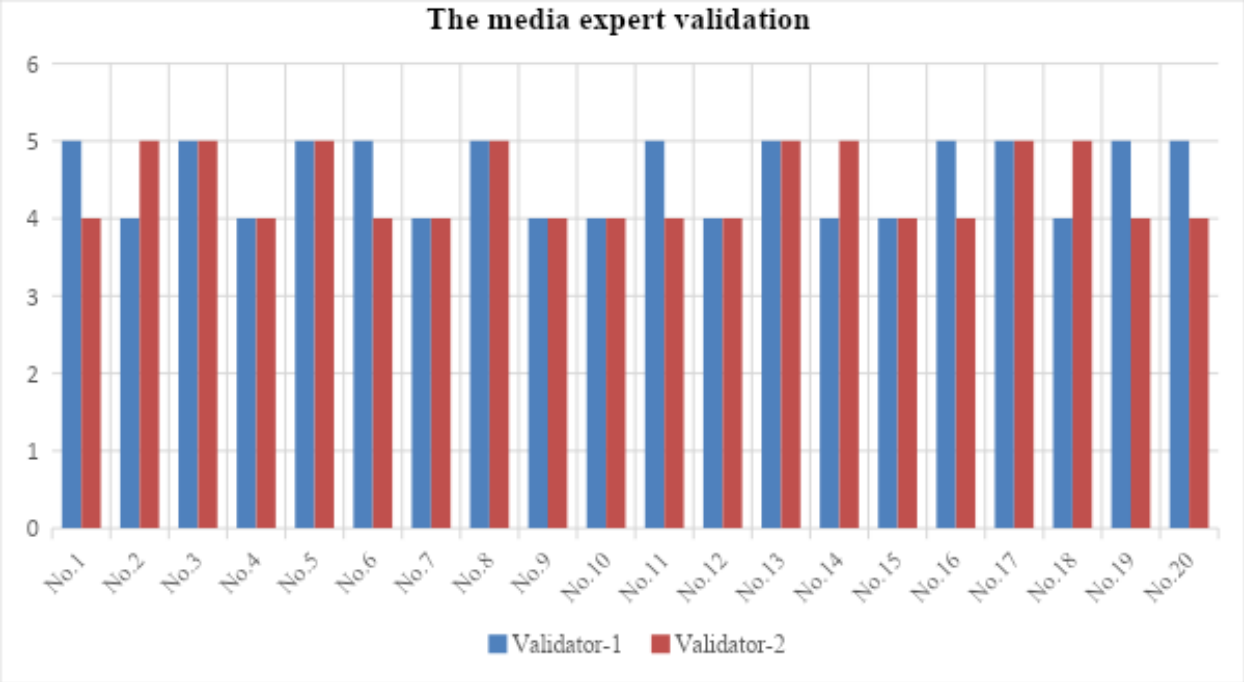

Figure 1. The Media Expert Validation

Apart from media expert validation, in testing feasibility, material expert validation was also used, the results of which were in the very good category and the validation results of the two material experts can be seen in Figure 2.

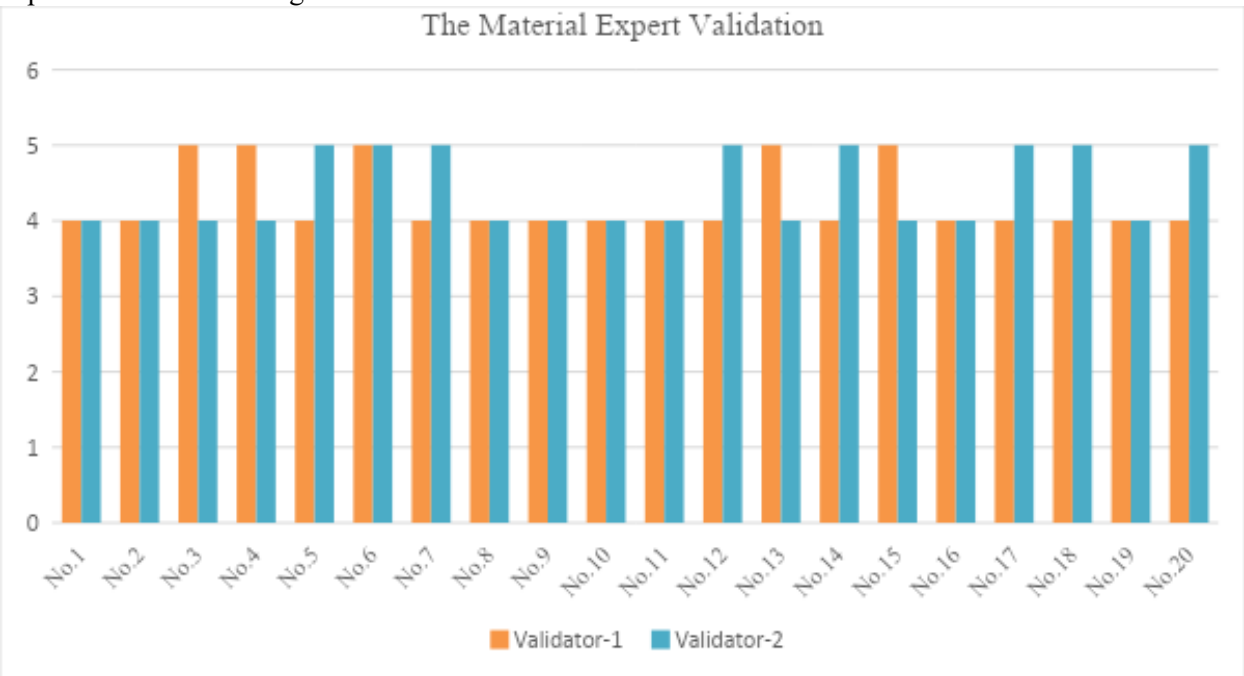

Figure 2. The Material Expert Validation

Products that have been developed and validated by media experts and material experts are then

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tested on students in the General Physics course. This trial was carried out to determine the practicality of the smart practicum guidance module that has been developed. The level of practicality regarding the use of the smart module application that has been developed can be seen from student responses. The research results of student responses consisted of 20 students with an average of 70.2% and were included in the practical category.

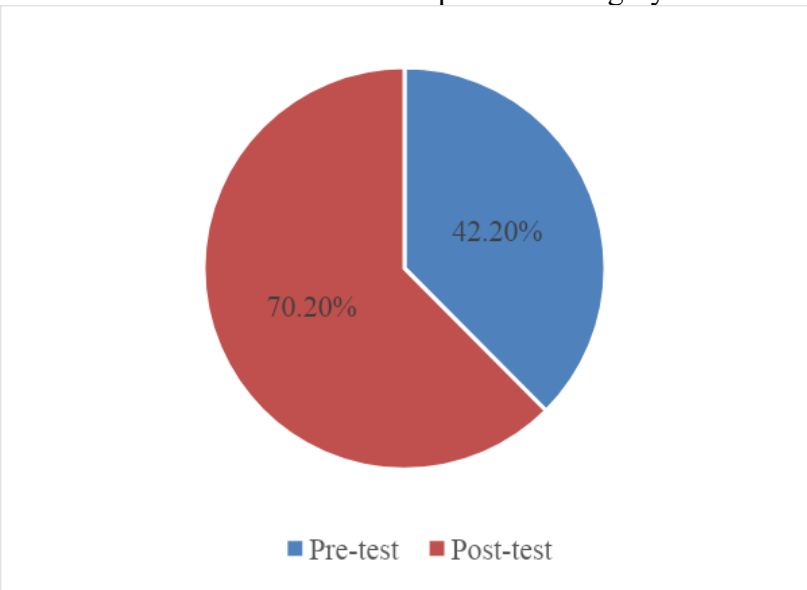

Figure 3. Effectiveness Test Results

Product effectiveness data was obtained from the results of trials on 20 students. Effectiveness can be seen from the test results of the ability to understand physics concepts after carrying out the practicum. There are two types of data, namely pre-test scores obtained from students' initial ability tests and post-test scores obtained from the final test results after the learning process using the smart module application. The following are the results of the pre-test and post-test data analysis.

The final step is product deployment, which occurs after the product being developed is complete and ready to be assessed for validity, practicability, and effectiveness. Validation is carried out on various aspects of the product, including media, materials, and questions. The results of media validation by two media expert validators were considered very valid. Validation of the material by two validators also received a very valid category, as validated questions by two validators which received a very valid category. Next, a practicability test was carried out involving 20 respondents who considered the product to be very practical. Finally, to assess the effectiveness of the product, the results of the pre-test and post-test on understanding physics concepts were carried out involving 20 students. The results show that this product is very practical. Therefore, it can be concluded that the smart module practicum guide for general physics subjects has been proven to be valid, practical, and effective based on evaluation results on validation of media, materials, questions, student responses, as well as pre-test and post-test scores.

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Conclusion

The conclusions of this research are by the results of the validation that has been carried out. The validation results of the material questionnaire showed a very good category, the media validation questionnaire got a very good average, and the question validation questionnaire got a good category. Apart from that, after undergoing practicability and effectiveness tests, it can be concluded that the smart module practicum guide for general physics subjects is practical and effective in the learning context**.**

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Mobile Learning and Malay Culture: An Examination of Android-Based Learning Media Validation and Effectiveness

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Abstract. *In the Indonesian context, especially in areas rich in Malay cultural heritage, there is great potential to improve the quality of education by integrating local cultural values in learning. However, various problems have been identified that need attention to combine culture with technology-based physics learning. The very positive validation results from these two groups of experts clearly indicate that this learning media is very feasible to be used in the context of learning general physics with the integration of Malay culture. This can be seen from the results of the media expert validation test which obtained a score of 89.33% with a very decent category. Incorporating Malay Culture into learning media not only improves the quality of learning but also creates an inclusive and culturally rich learning environment. This contributes positively to the educational experience of the students and allows them to learn more effectively while preserving their cultural values. Cultural integration in learning media after going through expert validation of the material obtained a score of 85.32% with a very decent category.*

Keywords : Mobile Learning, Android, Learning Media

Introduction

Education is one of the main pillars of a nation's development, and quality education is one of the keys to its success (Syafii et al.). Indonesia which has a culture of various ethnic groups, especially in areas rich in Malay cultural heritage, there is great potential in developing learning processes that are closer to local culture. Education as a place to pass on culture certainly cannot be separated from cultural values (Ilyas and Alumu). Its implementation must be in accordance with the culture of the Indonesian nation. In the Indonesian context, especially in areas rich in Malay cultural heritage, there is great potential to improve the quality of education by integrating

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local cultural values in learning. However, various problems have been identified that need attention to combine culture with technology-based physics learning.

In the learning process, it is very important to include components of local wisdom in the local area in delivering lesson material (Nadlir). Local wisdom itself is a way for people to survive and socialize that has been running for quite a long time and is agreed to be followed by certain communities (Veronika et al.). Local wisdom itself is something very valuable that must be maintained and developed in everyday life. The learning process in schools has not applied the potential of local wisdom in the learning process.

One of the actions that can be taken is the development of physics learning materials that are closely related to Malay culture (Maryono et al.). This is not only aimed at improving students' understanding of physics concepts, but also to maintain and enrich the local cultural heritage. Studies in education have shown that incorporating cultural context into learning can have a positive impact on student understanding and motivation. Therefore, making physics learning materials that integrate elements of Malay culture is relevant to improve the quality of education in these regions.

Technological developments also affect the learning process, for example, e-learning can also improve learning outcomes (Irfandi Irfandi et al.). The use of technology in using Malay culture can also be done using e-learning (I Irfandi et al.). The use of technology-based media can also use Android applications that are increasingly attracting attention in the world of education. Android apps have the potential to make learning more interactive and engaging for younger generations familiar with digital technologies (Tanjung, Sudarma, et al.). However, to successfully implement this technology, it is important to consider some of the problems that may arise. First, the problem of technology availability and internet access in areas with Malay cultural background can affect the effectiveness of using Android application-based learning media (Tanjung, Rugaya, et al.).

The limited availability of technological infrastructure can be an obstacle in presenting efficient learning media. Secondly, it is important to consider how to integrate elements of Malay culture in physics learning media. How to combine these values and cultural elements so as to increase students' interest and understanding of physics concepts(Ainley and Ainley). In addition, the evaluation of the effectiveness of physics learning media related to Malay culture is also a concern. How to measure the effectiveness of this learning media in increasing understanding of physics concepts among students (Apriyanti et al.).

Method

The location of this research was carried out at FMIPA State University of Medan with research time in the odd semester of 2022/2023. The research population is all FMIPA students of Medan State University and the research sample is students who take General Physics at FMIPA Medan State University. The research method in this study uses Research and Development. This development research uses the MDLC (Multimedia Development Life Cycle) method. The MDLC development method consists of 6 stages, namely concept, design, material collecting, assembly, testing, and distribution.

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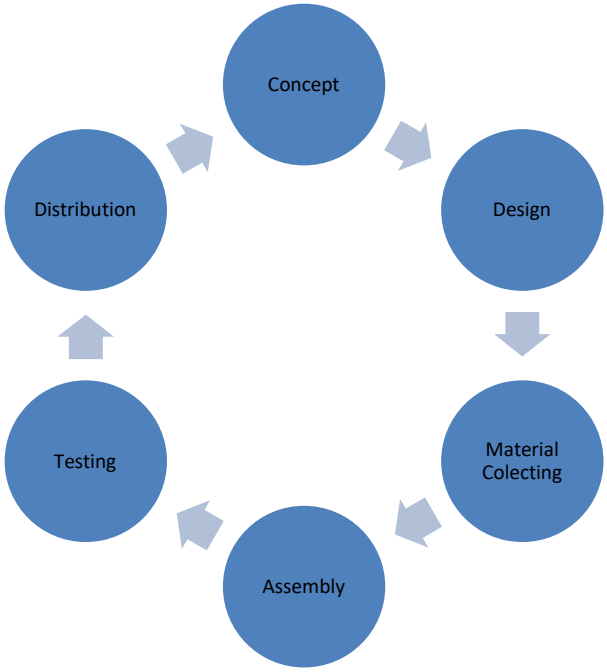

Figure 1. MDLC Research Design

The testing phase is carried out after completing the assembly stage by running the application / program and seeing whether there are errors or not. At this stage, media system testing is carried out by paying attention to application details such as the appearance of the application, the functions in the application, and the suitability of the function flow in the application, while for the content material contained in nature pay attention to the content, material, and achievements to be achieved from this media.

Data collection techniques in this study used questionnaires or questionnaires. Observation, in this technique, the research provides questionnaires using the Likert scale to media experts, material experts, and provides response questionnaires to physics education students who take IT-Based Educational Media Development Design courses.

Results

Application system testing results using validation from media experts using three main components with the following details: Evaluation of Application Content and Navigation, Evaluation of Technical Aspects of Application, and Integration of Malay Culture. For the results of expert validation can be seen in the following table

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Table 1. Media Validation Results

Component	Sub Components	Indicator	Average
Section 1: Content Evaluation and Application Navigation	Evaluation of the content of the application:	- Whether the content of this application is in accordance with the targeted curriculum or subject matter?	4
		- Whether the content of the application is easily understood by students?	5
		- Whether the content of the application is presented in an interesting and interactive way?	5
	Navigation evaluation:	- How easy the app is to navigate?	5
		- Are in-app menus and links easy to access and understand?	5
		- Are there clear instructions or guidelines on how to use the app?	4
Section 2: Evaluation of Technical Aspects of Application	Technical performance evaluation:	- Does this app run smoothly without significant glitches or bugs??	4
		- How quickly the app responds to user actions?	4
		- Is this app compatible with various Android devices?	4
	User interface (UI) design evaluation:	- How do you rate the user interface (UI) design of this application?	4
		- Does the UI design support effective and attractive use?	5
		- Do the colors, fonts, and other visual elements fit the theme of Malay culture?	5
Section 3: Evaluation of Malay Cultural Integration	The extent to which elements of Malay culture are integrated in this application?	- Is the use of Malay relevant and consistent in the application?	4
		- Does the app include significant Malay cultural values?	5
		- Are Malay cultural symbols used appropriately and meaningfully?	4

From table 1 we can see that the content evaluation and navigation components have sub-components Application content evaluation and Navigation evaluation. The content evaluation of the application obtained an average score of 4.67 and the navigation evaluation obtained 4.67. for components, the evaluation of technical and application aspects has two sub-components, namely technical performance evaluation and user interface (UI) design evaluation. Technical performance evaluation obtained an average of 4 and user interface (UI) design evaluation obtained 4.67. For the Evaluation Component, Malay cultural integration looked at the extent to which Malay cultural elements integrated in this application obtained an average score of 4.33. For Eligibility Presentation can be seen from table 2.

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Table 2. Media Eligibility Results

Media Credential Components	Average rating
Evaluation of the content of the application:	4,67
Navigation evaluation:	4,67
Technical performance evaluation:	4,00
User interface (UI) design evaluation:	4,67
To what extent are elements of Malay culture integrated in this app	4,33
	89,33%
Feasibility Presentation	Very Worth It

The results of material expert validation have five indicators, namely evaluation of the accuracy of physics concepts, evaluation of material completeness, evaluation of Malay cultural integration, evaluation of the quality of Graphics and Animation, and evaluation of Interactivity. For more details the results of this study can be seen in table 3.

Table 3. Material Expert Validation Results

Material Expert Indicators	Average
Evaluation of the Accuracy of Physics Concepts	4,33
Evaluation of Material Completeness:	4
Evaluation of Malay Cultural Integration	4,67
Evaluation of Graphics and Animation Quality:	4,33
Interactivity Evaluation:	4
	85,32%
Validation Presentation	Very Worth It

from table 3 above we can see that the evaluation of the accuracy of physics concepts has an average of 4.33, the evaluation of the completeness of the material has an average of 4, the evaluation of Malay cultural integration has 4.67, the evaluation of the quality of graphics and animations has 4.33 and the evaluation of interactivity has an average value of 4. From table 3 above, we can see that it has a material feasibility percentage of 85.32% which is categorized as feasible.

Discussion

In this study, through a validation process by media experts and material experts, this study explores the integration of Malay culture in Android-based learning media, especially mobile learning applications. The very positive validation results from these two groups of experts clearly indicate that this learning media is very feasible to be used in the context of learning general physics with the integration of Malay culture. This can be seen from the results of the media expert validation test which obtained a score of 89.33% with a very decent category. Incorporating Malay Culture into learning media not only improves the quality of learning but also creates an inclusive and culturally rich learning environment. This contributes positively to the educational experience of the students and allows them to learn more effectively while preserving their cultural values. Cultural integration in learning media after going through expert validation of the material obtained a score of 85.32% with a very decent category. Therefore,

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this study confirms the importance of considering local culture in the development of technology-based learning media for more holistic and relevant education, with the validation of media experts and material experts who strongly support its success.

Conclusion

The results of this study, which included validation by media experts and material experts, underscore the importance of integrating Malay culture into Android-based learning media, especially Mobile Learning applications. The findings of this study suggest that the validation process, involving media design experts and subject matter experts, consistently confirms the efficacy and cultural relevance of learning media. This dual validation approach not only confirms the quality and suitability of Android-based learning materials, but also proves its effectiveness in creating a culturally and pedagogically enriched mobile learning environment, thus enriching the learning experience.

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Optimizing Learning With the Case Method and Team Based Project in the Subject of Measurenment and Assessment of Learning Physics

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Abstract. *There are demands for case-based learning and team-based projects in the independent learning and independent campus curriculum, so the University formulates 6 tasks into the results of case methods and team-based projects. The physics learning measurement and assessment course is one of the compulsory subjects in the Physics Education Study Program, FMIPA, Medan State University. This study aims to: 1. Know the case method-based learning design and team-base project in the Physics Learning Measurement and Assessment course. 2. Knowing the implementation of case method-based learning and team-base projects in the Physics Learning Measurement and Assessment course. 3. Knowing the learning outcomes based on the case method and team-base project in the Physics Learning Measurement and Assessment course. The research method used in this study is the research and development (R&D) method with the ADDIE development type which uses five stages of development. The stages that will be carried out are: (1) Analysis (2) Design; (3). Development ; (4). Implementation ; and (5). Evaluation. The research results achieved show that the Assignment Case Methode and Tam Based Project formats are feasible to use based on expert validation. The implementation of the case method and team based project learning results in critical and creative thinking skills, so that student learning outcomes become better.*

Keywords : Case Method, Team Based Project, Measurentment, Assessment, Learning Physics

Introduction

The demands from the Ministry of Education, Culture, Research and Technology relate to learning in higher education which refers to the Main Performance Index (MPI) which aims to produce graduates who have 21st century skills (critical thinking, creative thinking, communication and collaboration). Based on the MPI, there are two criteria that must be

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obtained, namely: 1) Criteria for learning methods in class must use one or a combination of case-solving learning methods or team-based group learning. 2) Evaluation criteria: 50% (fifty percent) of the final grade weight must be based on the quality of class discussion participation (case method) and/or final presentation of project-based group learning (team-based project).

In the implementation of learning using the case method and team-based projects, in the last 2 years, in the Physics Education Study Program, it seems that this has not been optimal. As stated by the quality assurance team at the Faculty level, based on the results of the course learning outcome (CLO) evaluation of courses in each study program, there are still many CLO that do not include case method and team-based project based learning activities, independent learning Curriculum. The CLO for the Physics Education Study Program (PESP) course already exists, but it still does not accommodate comprehensively the implementation of case method and team-based learning. based project. From the CLO created, it is true that there are learning activities that accommodate the case method and team-based projects, but there is no instrument to measure the implementation of the learning.

Based on the assessment reference that has been issued by Medan State University, which is contained in the Regulation of the Chancellor of Medan State University Number 004 of 2022 concerning Guidelines for Assessment of Learning Outcomes at Medan State University. In the Chancellor's Regulations, it can be seen that student learning outcomes have the largest proportion of 50% in the portfolio assessment, namely the results of student assignments consisting of routine assignments (RA), critical book reports (CBR), critical journal review (CBR), idea engineering (IE), mini research (MR) and project (Pr). These 6 tasks are typical of assignments in lectures at Medan State University, which have been carried out since the implementation of Indonesian National Qualifications Framework (INQF) in 2016. With the demand for case methodology and team-based project learning in the learning center and campus school curriculum, the University formulated 6 tasks into case method and team-based project achievements with a percentage formula, where the combination of TR, CBR, CJR, and RI is the assessment for the case method and the combination of TR, CBR, CJR, RI and MR is the assessment for the team-based project.

Student problem solving ability is the ability of students to use the knowledge they have to solve problems in everyday life and must be possessed by students because problem solving is able to motivate students to develop their own theories, then evaluate them and evaluate their friends' theories, as well as verify other people's theories. (Hidayat et al., 2017).

According to Wena (2011:145) quoting Thomas, project-based learning has several principles in its application. These principles are: 1. Centralistic This means that this learning model is the center of the learning strategy, because students learn the main concepts of knowledge through project work. Project work is the center of learning activities carried out by students in class. 2. Guiding questions This means that the project work carried out by students is based on questions or problems that guide students to discover concepts about a particular field. In this case, work activities become external motivation which can generate internal motivation in students to build independence in completing assignments. 3. Constructive investigation This means that in project-based learning there is an investigation process carried out by students to formulate the knowledge needed to work on the project. Therefore, teachers must be able to design learning strategies that encourage students to carry out the process of searching and/or deepening knowledge concepts in order to solve the problems or projects they face. 4. Autonomy In project-based learning, students are given the freedom or autonomy to determine their own targets and

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be responsible for what they do. Teachers act as motivators and facilitators to support students' success in learning. 5. Realistic The projects carried out by students are real work that corresponds to reality in the workplace or on instruments. The projects carried out are not in the form of simulations or imitations, but rather real work or problems. Referring to the principles mentioned above, learning by implementing project based learning will be very beneficial for students' self-development and future. Students who are used to learning through project work will become tenacious, critical, independent and productive individuals.

Methodology

The research will be carried out at the Physics Education Study Program, FMIPA, Medan State University on even semester 2022/2023. This research is a type of development research or Research and Development (R&D), which aims to develop a new product or improve an existing product. This research is instrument development research (educational research and development) which aims to develop learning in physics learning measurement and assessment courses..

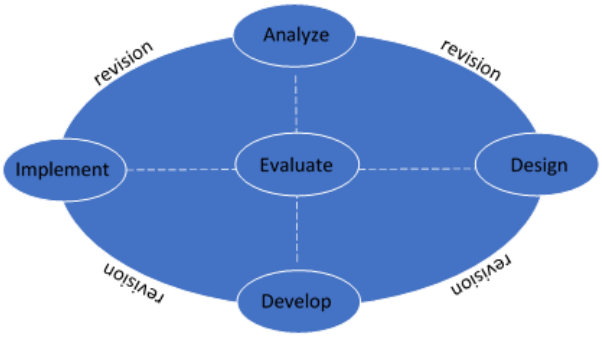

Figure 1. ADDIE development type research design

This development research uses the ADDIE development type which uses five development stages, namely: 1) Analysis, namely carrying out needs analysis. Identifying problems, identifying products that suit the target, thinking about the products being developed, 2) Design, the design stage is designing the concept of the product to be developed, 3) Development, development is the process of making the design a reality, 4) Implementation, implementation is product trials as a real source for implementing the product being made, and 5) Evaluation, namely the process of seeing whether the product being made is successful, in accordance with initial expectations or not.

Result and discussion

1. Analysis

At this stage, the curriculum implemented at FMIPA Unimed is analyzed, where Unimed has implemented a Curriculum oriented towards the INQF starting in 2016, the assessment of which is determined in the Chancellor's decree. One of the distinctive characteristics of the implementation of the INQF is the implementation of 6 tasks with a detailed explanation of the 6 tasks, namely: a) Routine tasks provide meaning for practicing all the competencies in the lecture contract, with assessment indicators being attitudes, knowledge and skills. b) Critical Book

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Report (CBR) provides the meaning of reviewing a book based on concepts or theories studied in a course to determine a critical position. Assessment indicators include 1) problem summary; 2) consider context and assumptions; 3) communicate one's own perspective, hypothesis or conjecture; 4) analysis of supporting data and evidence; 5) using other perspectives and conjectures; 6) examine conclusions, implications and consequences; and 7) communicate effectively. c) Critical Journal Review (CJR) means reviewing (all components of a research) or journal critically with the main aim of finding the strengths and weaknesses of a research/journal and presenting relevant suggestions to maintain the strengths and overcome the weaknesses of the research/journal. Indicator. Assessment indicators include: 1) summary of the background to the research problem; 2) consider context and assumptions; 3) communicate one's own perspective, hypothesis, or conjecture; 4) analysis of supporting data and evidence; 5) using other perspectives and conjectures; 6) examine conclusions, implications and consequences; and 7) communicate effectively. d) Idea Engineering (RI) gives meaning: a) derivation of new ideas or concepts from existing ideas and new ideas in the same or different social context, creation and innovation from existing ideas, b) potential to produce real products, c) wild ideas that are tamed. The assessment indicators include: 1) ability to generate ideas; 2) describe ideas; 3) Write down engineered ideas; 4) Using the latest references; 5) Integration Skills. e) Mini Research (MR) provides the meaning of simple research which at a minimum consists of questions (hypothesis, objectives, main points), theory, instruments, data collection, data analysis and conclusions. The assessment indicators include: 1) Recency and originality; 2) suitability of goal formulation; 3) relationship between elements; 4) instrument suitability; 5) suitability of data analysis techniques; 6) main findings; and 7) implications. f) The project provides meaning: a) the application of knowledge transfer for authentic problem solving through the process of investigating ideas, the inquiry process, critical and creative thinking, as well as skillfully communicating the results. b) produce models or products that have ethical, aesthetic, social, cultural and economic values. The assessment indicators include: 1) Inquiry ability in investigating ideas and questions; 2) Ability to apply scientific concepts and principles learned in various relevant scientific fields; 3) The ability to think creatively in solving problems (fluency, flexibility, elaboration, and novelty of solving strategies); 4) Ability to manage resources to complete tasks; and 5) Reporting capabilities

Through these 6 assignments, students are expected to be able to develop their abilities in expressing inspirational and creative ideas. By doing routine assignments, students can achieve competency in each material taught. Critical Book Report and Critical Journal Review assignments will foster students' critical attitudes. So, by doing CBR and CJR assignments, students can do reasoning and thinking in solving a problem. Providing Idea Engineering, Mini Research and Project assignments has an impact on students in the habit of providing ideas or good ideas for self-development to the students themselves, as well as to transfer the knowledge they understand so that the learning process is more meaningful.

Apart from that, the aim of giving 6 tasks is also expected to be able to implement the 10 characters recommended by Medan State University, namely: 1) communication ethics, 2) Honesty, 3) Responsibility, 4) Cooperation, 5) Toughness, 6) Caring, 7) Discipline, 8) Perseverance, 9) Independence, 10) Initiative.

Next, an analysis was carried out of the learning outcomes of the Physics Education Study Program and the learning outcomes of the Physics Learning Measurement and Assessment course as follows:

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Table 1. Learning Achievements of the Physics Education Study Program

Study Program Learning Achievements	
A	Have a professional attitude and openness to collaborate and have social sensitivity and concern for society and the environment for the development of learning
K	Mastering the concepts of physics, the scientific mindset of physics based on natural phenomena which is needed to carry out learning in primary, secondary and advanced education units
GS	Able to apply logical, critical, systematic and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies humanities values in accordance with the field of Physics Education based on scientific rules, procedures and ethics in order to produce solutions, ideas and designs.
SS	Able to utilize various alternative solutions to physics problems that are available independently or in groups to make appropriate decisions in the field of education in classroom learning, physics laboratories and educational institutions for which they are responsible.

Tabel 2. Course Learning Outcomes (CLO)

Course Learning Outcomes (CLO)	
CLO-1	Understand the relationship between assessment and curriculum and learning instructions through the form, function and purpose of assessment.
CLO-2	Applying strategies to construct valid and reliable instrument indicators through authentic assessment.
CLO-3	Evaluate the advantages and disadvantages of types of assessment for various types of learning outcomes assessment instruments (objective, performance, etc.).
CLO-4	Analyze assessment instruments and data to make decisions related to learning instruction
CLO-5	Designing the development of authentic-based instruments (Performance, Higher Order Thinking skills, Observation, Scientific Attitude, Teamworks) that are valid and reliable based on indicators of assessment needs.
Sub-CLO	
Sub CLO-1	Able to explain and identify knowledge of assessment, measurement, assessment indicators and descriptors, functions and objectives of tests and non-tests.
Sub CLO-2	Able to apply various methods of assessment, measurement, assessment and evaluation of physics learning results and processes.
Sub CLO-3	Able to formulate learning objectives and assessment indicators based on cognitive (Bloom and Bloom revisions), performance (Simpson and Harrow), and scientific attitudes (Krathwoll).
Sub CLO-4	Able to analyze and evaluate the use of measurement methods and instruments in research and assessment of Physics learning
Sub CLO-5	Able to formulate and design instrument development grids and assessment rubrics based on Learning Assessment (Cognitive, Performance and Scientific Attitude).
Sub CLO-6	Able to develop and analyze various scientific attitude instruments based on taxonomy
Sub CLO-7	Able to develop and analyze laboratory performance tests based on taxonomy
Sub CLO-8	Able to design and analyze inquiry tests, creative, innovative critical thinking tests, higher order thinking skills tests based on taxonomy

Design

a. Design for case method assignment

CASE METHODS

Material Deepening: Students individually and in groups solve cases in the process of developing instruments to measure: (1) Knowledge competency, (2) skills, (3) attitude, (4) various types of high-level thinking skills. to carry out analysis (measurement components, assessment,

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instrument design, relevant theories, types of data and analysis techniques, data interpretation and conclusions.

Case presentation : A case of developing an assessment system based on a study of the international journal Physical review physics education research according to the topic of deepening the respective material is presented.

Case solving:

1. Data search : Students are asked to observe and identify components of measurement, assessment, evaluation, indicators, studies, theoretical basis, data analysis techniques, discussion and interpretation of data.
2. Submission of ideas : Students propose solutions to overcome relevant problems or cases.
3. Validation : Students validate the planned solution based on references from research articles related to problems that have related problem studies.
4. Solution Formulation : students formulate solutions to overcome problems based on references from articles and discussions
5. Writing work results : Students write down problems and solutions in overcoming problems with types of instrument development that are relevant to the case at hand.

Presentation : Students making presentations are selected randomly by looking at the different solution offers.

Class discussion : Lecturers and students hold discussions by providing responses to the solutions proposed during the presentation to find the most appropriate solution to solve the problem.

Assessment and feedback : Lecturers provide assessments and input on the results of observations and solutions produced by students.

b. b. Design for team based project assignments

TEAM BASED PROJECT

Introduction to material/concepts : Students are asked to design an assessment system development project (Knowledge, skills, attitude, type of thinking skills, etc.)

Group formation : Students are divided into several groups according to the previous case method.

Project assignment :

Students are asked to formulate problems and solutions in the form of products (assessment instruments) regarding things that occur in the instrument development process.

Project implementation :

1. Project planning and time schedule : The group determines the framework for developing assessment instruments.
2. Data search : Make observations using an investigation sheet on what things are needed in order to develop assessment instruments
3. Submission of designs/ideas : Looking for solutions through engineering appropriate ideas to overcome problems in the implementation of the educational assessment system referring to the results of CJR, CBR.
4. Discussion and validation : Students discuss in groups to complete the report
5. Writing Work Results : Designing a product in the form of a draft for implementing a modern education assessment system from the results of mini research.

Report : Create reports and complete e-draft assessment instruments or videos on the

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implementation of modern education assessment systems based on the latest assessment theory.
Presentation of Product Results : Presentations are made to show students' communication skills in taking responsibility for the results of completed projects.
Assessment and feedback : Lecturers provide product assessments and feedback in the form of input for product improvement.

Validation

The Case Method and Team Based Learning Assignment Format that was created was then validated by 3 experts from the physics education study program. The validation results of the Case Method and Team Based Project assignment format showed that the assignment format was very suitable for use in lectures on the Physics Learning Measurement and Assessment course. , as in the following table:

Table 3. Validation results by 3 expert teams

Validator	validator score	Advisability category
Material expert	87,67	Very feasible
Design expert	86,33	Very feasible
Language expert	88,67	Very feasible

Implementation

Implementation of case method and team based project based learning runs in one semester. The case method is carried out in the form of a literature study assignment by looking for problems in assessment in schools through articles in journals and field studies by conducting interviews with physics teachers at schools. The results of the literature review and interviews were made in the form of a case method report.

Implementation of team based project learning in the form of making instruments and test assessment rubrics which are tested in schools so that an instrument product and assessment rubric can be obtained which can be used as a reference. The process of implementing case method and team based project learning is reflected on students by providing student response questionnaires. The results of the student response questionnaire can be seen in the following table:

Table 4. Student responses to case method and team based project assignments

Assignment	VI	I	QI	LI	NI
Case Method	92,11	7,89	-	-	-
Team Based Project	86,84	13,16	-	-	-

Where : VI : very interested; I : Interested; QI : Quite Interested; LI : Less Interested dan NI : Not Interested

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Evaluation

Evaluation is carried out at each stage of this research with the aim of knowing the results obtained at each stage of the research and the improvements that must be made so that the results obtained are in accordance with the research objectives.

Conclusion

From the results of the case method and team based project based learning design, a learning assignment format was produced that was suitable for use in the learning process with a very suitable category based on validation from material, design and language experts. The results of student responses to the implementation of case method-based learning were 92.11% of students said they were very interested and 7.89% were interested. In implementing team based project learning, 86.84% of students said they were very interested and 13.16% of students were interested.

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The case method as an assessment a practical approach to wave superposition learning

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Abstract. *Superposition of mechanical waves in the learning process is mostly presented in the form of solving cases, but often encounters several obstacles. The main obstacle stems from the difficulty in determining the completion steps from a mathematical and visual graphic side. The wave superposition case involves two cases, namely (1) the superposition of two waves with the same amplitude but different wave function (standing wave), (2) the superposition of two waves with different amplitude and different phase. Problem solving cases involve manual analysis and numerical analysis using computer assistance. The case method as an assessment approach with a structured template provides a more numerically and analytically directed solution. Data analysis shows that the use of the case method template provides better progress in increasing the ability of wave superposition analysis, especially for the case of wave superposition with different phases and amplitudes.*

Keyword: case methods, mechanical wave superposition

Introduction

The case method as part of learning assessment provides direction on how to design a solution plan according to differences in student abilities and the learning system developed by each group [1]. Case method templates and specific learning instructions were both developed with the aim of assisting the learning process, learning needs and critical attitudes. The case method has been successfully used to teach students in software engineering courses [1], wave superposition material as part of physics courses requires analytical and numerical skills using software such as Excel or Matlab.

Studies of several research material focuses related to waves in the field of physics education have been widely carried out [2–5], Coherence analysis between instructional programs and wave material assessment systems from various studies indicates the need to build a connection system. This connection system can be named as a learning template. The case method template provides a numerical solution overview and graphical representation. Problem solving

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instruction is still needed to carry out the problem-solving process analytically. The case method template plays an important role in developing wave superposition learning as a framework for building problem solving concepts.

Research questions:

1. How to apply template case methods as a practical implementation of alternative assessments to develop strategies for achieving wave superposition case learning outcomes.
2. See an overview of the effectiveness of implementing case methods for computer-based wave superposition cases compared to manual analysis.

Wave superposition

The importance of students' understanding of wave material covering four contents: propagation, superposition, reflection and standing waves [2]. The author stated how an assessment had been carried out to provide an evaluation of the understanding of the concept of mechanical wave material in the form of an essay test. The next measurement of understanding of mechanical waves uses multiple choice tests as a development step [3]. Recommendations from the research results provide a signal for evaluating the teaching process of mechanical wave material.

Learning resources need to be developed in various forms. The aim is to improve the understanding of mechanical waves through a relevant instructional system [4]. Several approaches can be used in wave learning. The traditional approach uses a sinusoidal curve, using a series of static images, and a time function electric field oscillation approach [5].

Case methods as a formative assessment system

Case methods as a formative assessment system try to help provide an assessment of the process of finding a solution for the wave superposition case. Case methods developed as minimum standards for formative assessment systems can be expressed in the form of a basic template, which is able to provide direction for case solutions that can be assessed in the assessment system. Formative assessment as part of teaching and learning can be seen as something practical in increasing students' overall motivation and competence to achieve learning success and improve learning outcomes [6].

Formative assessments can take several forms as alternative instruments. Case methods are implemented in template form as part of a formative assessment system in accordance with the teacher's or developer's systematic view [7]. Case methods as formative assessments can develop students' self-regulation to achieve learning goals effectively [8]. Formative assessment is developed by teachers as a learning designer. Teachers have an important role in implementing formative assessment to introduce a strategy for expanding learning outcomes [7].

Method

Participants

This research involved 35 students from the physics education study program. The research was carried out in the even semester 2022_2023 with Waves and Optics courses. Class members were randomized into two groups with 17 students in each group.

Research Design

This research was conducted to see the impact of using template case methods which have been designed to build wave superposition problem solving abilities. The review process is carried out

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by implementing treatment using templates for one group and other groups not using templates. The aim is to determine the steps to solve the wave superposition case. Formative assessment is carried out by providing an assessment of the process of finding solutions using a predetermined rubric. The research design was developed using a quasi-experimental design in Figure 1. This design was used to analyze the success between two groups given different treatments.

$$\begin{array}{lccc} Experimental & O_1 & X & O_2 \\ Control & O_3 & & O_4 \end{array}$$

Figure 1. Research design

Procedures for applying the case method template as a formative assessment

CM is a potential solution in developing students' abilities to solve problems using knowledge, skills and attitudes in lectures [9]. CM capabilities can be implemented effectively through the use of specially designed templates. The template provides direction in finding a solution to a case which can be viewed from the framework, planning, practical implementation and relevant assessment framework as shown in Figure 2.

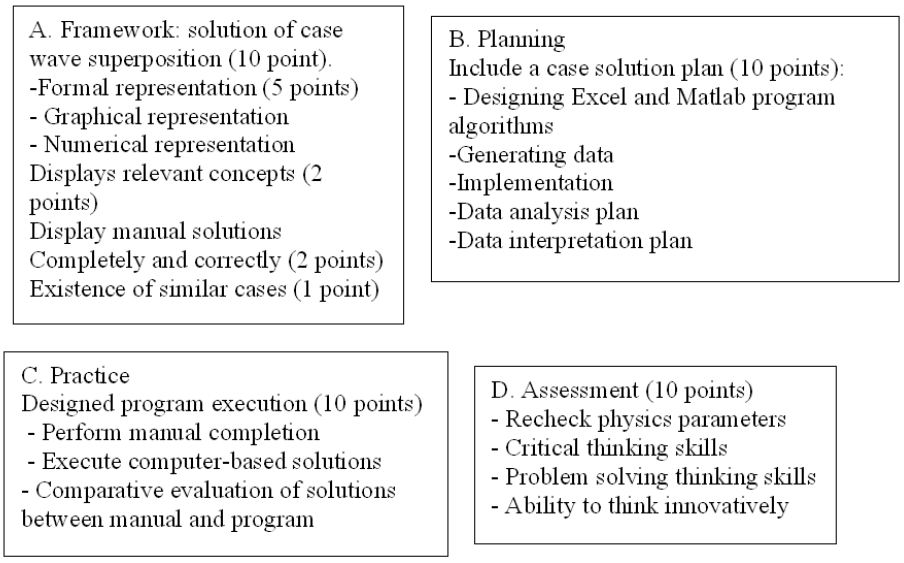

Figure 2. Template case method wave superposition

The case methods template is used by experimental group students to work on cases of superposition of sine waves. Guided by the template, students try to find their own solution to the problem according to the case at hand. Students can assess individually and as a group the progress obtained. The template is used as a formative assessment standard to assess the stages of solving wave superposition cases. This can be interpreted as a case resolution strategy using template case methods [9].

Result and discussion

Results

The achievement of the formative assessment shows that the case method template is able to provide strategic direction in finding a solution to the wave superposition problem. Comparison

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of score achievement data can be seen in Table 1 for the experimental and control groups.

Table 1. Characteristics of experimental and control class research

	N Statistic	Minimum Statistic	Maximum Statistic	Sum Statistic	Mean statistic	Std. Err	Std. Dev Statistic	Variance Statistic
experiment	17	78	95	1471	86.53	1.22	5.04	25.39
control	17	75	89	1380	81.18	1.35	5.60	31.40

The difference in the average score between the experimental class and the control class was 5.35 and the standard difference was 1.83 (Table 2). The assumption that the variance values between groups are different or not different is not a problem in calculating the average achievement score. Statistically the average scores of the two groups are very significantly different with a probability of .01 < 0.05. The average score of the experimental class is greater than the average of the control class.

Table 2. Differentiate the average formative scores using the t-test

score	Levenne's test for equality of variance		t-test for equality of means					
	F	sig	t	df	Sig.(2-tailed)	Mean difference	Standard error difference	
Equal variance assumed	2.59	.12	2.93	32	.01	5.35	1.83	
Equal variance not assumed	-	-	2.93	31.65	.01	5.35	1.83	

Discussion

The case method template provides a framework direction for constructing wave superposition case solutions. The stage that needs to be stated clearly and measurably is designing a case solution framework, starting with stating the problem into a formal representation. Next, create a manual solution design and computer-assisted solution to show numerical and graphical representations. Reviewing the solution design to see whether it is in accordance with the literature review and the scientific basis of physics. Reviewing the similarities between the case being worked on and other relevant cases to provide insight into the solution framework being offered.

The second stage of solving cases according to the template is designing a wave superposition solution display system using a computer. Write wave equation models in Excel and Matlab using relevant algorithms according to the case. The process of generating synthetic data and analysis that corresponds to the case of wave superposition to provide a graphical representation. Plan data analysis based on graphical results of wave superposition

The third stage according to the template directions is the activity of analyzing and comparing manual solutions and computer-based solutions. This activity is aimed at reviewing the accuracy of the wave superposition case solution. Manual solutions are carried out by reviewing several relevant formulas based on textbook and journal literacy. Likewise, the

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analysis of the use of computers to graphically and numerically show the superposition process and the analysis of wave equation formulas are relevant

The final stage of the template is to present a peer assessment to assess the physics parameter system. Checking the presence or absence of critical thinking in case solutions, problem solving thinking skills, and innovative thinking abilities.

The case study of solving the superposition of two sine waves with differences in amplitude and phase in Figure 3 is included in the high level of difficulty group. Case solutions can be solved manually using the standard sine addition formula. Another method that can be used is numerical analysis using Excel. The Matlab program can be used to find a solution, by first writing the m-file program coding [10]. The stages for completing case studies in the form of problem solving follow the template in Figure 2. Each student works independently or in groups according to the frame work template. The assessment process is carried out continuously according to developments in case resolution. A guide to the accuracy of answers has been provided, the steps for solving cases follow a template so that you can carry out the assessment independently.

The steps for solving the wave superposition case are carried out by: (1) identifying possible solutions to the wave superposition case, (2) reviewing the type of wave, amplitude and phase of each wave, (3) determining the manual solution frame work, (4) assessing and interpreting the results of the manual solution, (5) re-check.

The computer-based wave superposition solution step is carried out by carrying out the following stages: (1) preparing excel and m-file programs, (2) executing the input wave equation with Excel as in Figure 3 in blue and orange, (4) executing the input wave equation and The results using Matlab are as in Figure 4.

The final step is to compare the results numerically and graphically for both manual and computer completion methods. Critiquing the results of manual and computer-based analysis must have 100% accuracy.

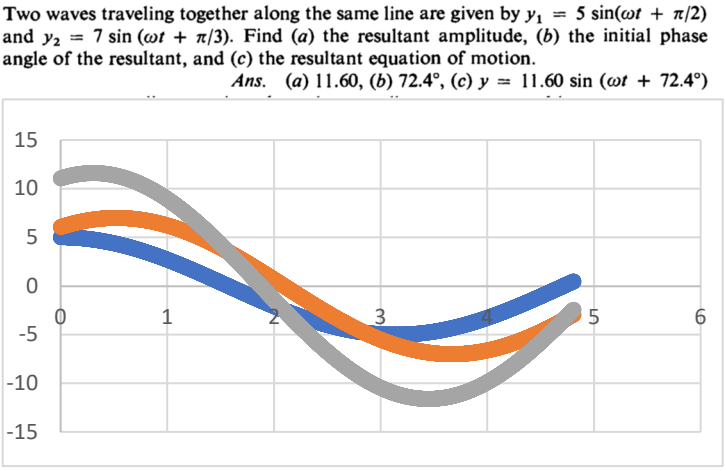

Figure 3. Problem and solution sinusoidal wave superposition based excel

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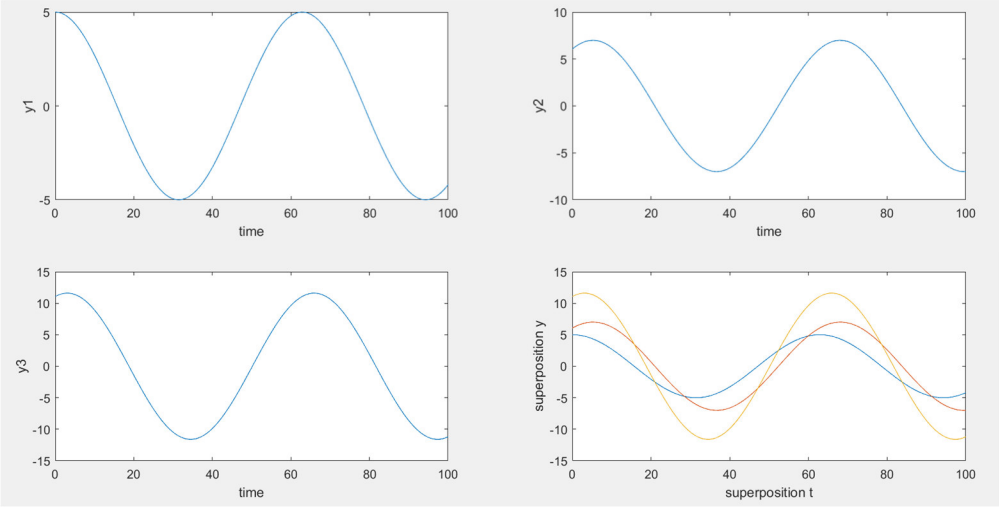

Figure 4. Problem and solution sinusoidal wave superposition based Matlab

Conclusion

Conclusions from using wave superposition templates to plan and find relevant solutions:

1. The wave superposition case template provides a more operational guide to achieving learning objectives
2. Students can assess individually and in groups the quality of the planned case solutions and the results achieved.

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Description of standing wave module based on stem

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Abstract. *The understanding concept of students in terms of waves is still low. Students consider that the concept of waves is too abstract so it is difficult to understand. The teaching materials that were used by educators still do not facilitate students to understand the concept of waves. Therefore, the objective of this research is to develop a STEM-based Standing Wave module. The results of this research are limited in terms of the Define and Design stages by elaborating the sub-topics, listing learning objectives and descriptions of the STEM aspects of the modules being developed. The results show that the developed module covers 4 STEM aspects, namely in the science aspect, it consists of explaining concepts related to presenting standing waves. In terms of technology, it consists of a virtual practicum using a standing wave simulator to determine the relationship between the shape of the pattern and the vibration frequency that produces standing waves on a string. In the Engineering aspect, it consists of a project of making a wave machine that can demonstrate the phenomenon of harmonic standing wave patterns. In the mathematical aspect, it consists of an explanation of the mathematical relationship between the wavelength that produces the pattern and the length of the medium is presented. This module can be utilized for scientific development and learning resources so as to improve mastery of physics concepts and train students' skills covering the four aspects of Science, Technology, Engineering and Mathematics.*

Keyword: standing wave, STEM

Introduction

One of topics in physics that really important to be studied and understood is wave [1-4]. Standing wave is a topic that cannot be separated from the scope of wave material. Standing wave is defined as the superposition of two waves that have the same frequencies and

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amplitudes, but propagate in the opposite direction. The understanding well in terms of standing wave will give impact on the whole understanding about wave, and its implementation can be used particularly in specific area such as spectroscopy, seismology, meteorology, engineering and electric [4]

In fact, the concept understanding of student correspond to wave is still low [5,6]. This is due to that student perceive that wave concept is abstract thus it is difficult to understand [4,7,8,9,10]. Another reason is that educators do not fully consider students' interests in the learning sources and tasks assigned by the wave. Overall, the teaching materials used by most educators still do not allow students to analyze problems based on everyday phenomena [3,11]. The content of teaching materials that are used are still abstract without being linked to the environment and students' lives in daily phenomena [12, 13]. Textbooks that are used by students as one of learning resources still do not fully help students mastering in physics concepts and their application in their daily lives [3, 14].

The solution that can be given to overcome this problem is by using teaching materials that foster student activity so they can learn independently [15, 16]. This teaching material can make students easier to understand the material. One type of teaching material that suits these needs is a module based on Science, Technology, Engineering and Mathematics (STEM) [17,18]. The application of STEM-based learning modules will address several cases of real problems related to standing wave studies for students. By applying the four main aspects of STEM, it is hoped that students can improve their mastery of concepts and develop their scientific thinking process skills and create active and enjoyable learning conditions [19,20,21]. Learning with STEM-based modules can increase students' activeness and learning outcomes, thus give impact on understanding abstract concept of Standing Waves [22].

Many studies have developed STEM-based modules but those that focus on the topic of Standing Waves are still very limited. Therefore, the aim of this research is to develop a STEM-based Standing Wave module that can be used to improve students' conceptual understanding. This article consist only outlines the sub-topics, learning objectives and descriptions of the STEM aspects of the module being developed.

Method

The development of the STEM-based Standing Wave module in this study uses a 4D development model with four stages, namely Define, Design, Develop, and Disseminate. The research results in this article are limited to the Define and Design stages with the aim of outlining a description of the material content including sub-topics, learning objectives and a description of the STEM aspects of the module being developed. Activities carried out at the define stage are determining and compiling a needs analysis which includes material analysis and learning objectives. Material analysis was carried out to map the Standing Wave sub-topic and its relationship to concrete phenomena and examples that exist in everyday life. Analysis of learning objectives is carried out to determine learning indicators in accordance with the standing wave material.

Activities carried out at the design stage are determining the module format, designing material content based on sub-topics, designing practicums and compiling instruments. All these components will be included in the module. The preparation of module content contains four aspects of STEM, namely Science, Technology, Engineering and Mathematics. This study is

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limited to only describing sub-topics, learning objectives and descriptions of the STEM aspects of the module being developed

Result and Discussion

Standing wave sub-topic analysis

The STEM-based Standing Wave Module is designed based on material analysis and learning objective analysis. The material is detailed in the form of sub-topics in accordance with the learning objectives. Descriptions of sub-topics and learning objectives are presented in Table 1.

Table 1. Sub topics and learning objectives of module

Component	Details
Sub Topic	- Traveling Waves versus Standing Waves - Formation of Standing Waves - Nodes and Anti-nodes - Harmonic Waves and Standing Wave Patterns - Standing Wave Mathematics - Standing Wave Resonance
Learning objectives	- Understand that the wavelength and frequency of a wave are related to each other by the speed of wave propagation, which depends on the type of wave and the medium through which waves travels. - Describe the difference between standing waves and traveling waves and explain how standing wave patterns on strings are formed from the interference of two waves. - Create a standing wave pattern diagram for various harmonic waves from a vibrating string/string and identify the harmonic number for each pattern. - Describe what nodes and antinodes are and identify their location on a standing wave pattern. - Know the mathematical relationship between wavelength and string/string length for various string/string harmonic waves - Mathematically analyse situations involving standing waves in guitar strings to relate harmonic numbers, string length, wavelength, frequency, and speed.

The first sub-topic, namely standing waves versus traveling waves, contains description of the differences between these two types of waves. This becomes basic knowledge for understanding the next material. Students often experience the misconception that standing waves are the same as traveling waves [23,24]. Even though these two concepts are different, a traveling wave is a wave that propagates without limited to a certain space throughout the medium, while a standing wave is a wave that propagates limited to a certain space in a medium and still produces a regular and easily observable wave pattern. Students' misconceptions about these waves can be overcome with a correct explanation of the concept presented in a module.

Understanding the concept of standing waves increases by studying the formation of standing wave patterns. In this module, standing wave patterns are presented through the example of a slinky movement with the explanation that standing wave patterns are produced as a result of repeated interference of two waves of the same frequency when moving in opposite directions

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along the same medium. The aim of using a slinky is to present a more concrete standing wave pattern so that it is easier for students to understand. Abstract physics concepts such as standing waves need to be presented in a more concrete and contextual way to reduce the potential for misunderstanding [25].

Another important sub topic is Nodes and Anti-Nodes. All standing wave patterns consist of nodes and antinodes. Nodes are points without displacement caused by the destructive interference of two waves. Antinodes result from the constructive interference of two waves and thus experience maximum displacement from rest. There are misconceptions in understanding Nodes and Anti-Nodes [26,27,28]. One of them is that students consider Anti-Nodes as peaks or troughs. In this module it has been clearly explained that the Anti-Node is actually a point that oscillates back and forth so that it helps students to recognize that this antinode point can "rise" and "fall" (one and a half cycles later) rather than being called a peak or trough.

The next sub topic is Harmonic Waves, standing wave mathematics and standing wave resonance are advanced material presented in the module. These three sub-topics are presented using examples such as Harmonic waves shown by the wave pattern produced by a slinky and resonance in a musical instrument. This aims to overcome misconceptions among students.

The formulation of learning objectives (Table 1) represents the achievements of sub-topics and is adjusted to the depth of the topic. Achieving learning objectives starts from students being able to understand wave quantities such as wavelength and wave frequency to students being able to analyze the application of standing waves to musical instruments such as guitars.

Analysis of STEM aspects in modules

STEM-based modules guide students to learn in four aspects, namely Science, Technology, Engineering and Mathematics so that studying wave material becomes more meaningful and students experience in collaborating four aspects of STEM [29,30]. The developed module covers the four aspects of STEM which can be shown in following table.

Tabel 2. Description of STEM aspects in the module

Aspects	Description
Science	Formation of standing waves, the concept of nodes and antinodes and standing wave resonance
Technology	Virtual practicum using standing wave simulator
Engineering	The project to make a wave machine by using rope, PVC pipe and fittings, a battery, two motors and some wire
Mathematics	For standing wave patterns, there is a clear mathematical relationship between the wavelength and the length of the medium that produces the pattern. The mathematical relationship simply emerges from examining the pattern and understanding that each loop in the pattern is equivalent to half a wavelength

In the science aspect, concepts related to standing waves are presented. Starting from the differences between standing waves and traveling waves, standing wave patterns, nodes and anti-nodes and resonance as well as explaining the concept of standing waves through application to musical instruments such as guitars. This sub-topic contains science aspect that can be used by student to understand and relate it to other science material. Understanding science opens up new minds in other fields of science [31].

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In the technological aspect, a virtual practicum using a standing wave simulator is presented to determine the relationship between the shape of the pattern and the vibration frequency that produces standing waves on the rope. The practicum is equipped with a guide for carrying out virtual activities, an observation table and an analysis section of the practicum results. Through virtual practicums, students can practice their scientific process skills as well as technology skills.

In the Engineering aspect, a project is presented to make a wave machine using tools and materials, namely rope, PVC pipe and connections, batteries, two motors and several wires. Wave machines can demonstrate the phenomenon of harmonic standing wave patterns. This activity can improve students' understanding of wave patterns and train creative thinking and technical skills [32,33].

In the mathematics aspect, an explanation of the mathematical relationship between the wavelength that produces the pattern and the length of the medium is presented. The mathematical relationship simply emerges from examining the pattern and understanding that each loop in the pattern is equivalent to half a wavelength. Apart from that, there are several sub-topics that use mathematical relationships such as the relationship between quantities such as wavelength, frequency and amplitude in standing waves. Mathematics as a tool to help describe the relationship between physical quantities quantitatively. Physics problems can be solved using mathematical calculations so that students who study physics concepts can simultaneously practice their mathematical skills [34].

This STEM-based standing wave module has been completely designed to be used as teaching material for students. This module can be used to develop knowledge and learning resources so that it can improve mastery of physics concepts and train students' skills covering four aspects of Science, Technology, Engineering and Mathematics.

Conclusion

The STEM-based Standing Wave Module has developed focuses on the sub-topics of traveling waves versus standing waves, standing wave formation, nodes and anti-nodes, harmonic waves, standing wave patterns, standing wave mathematics and standing wave resonance. The module covers four aspects of STEM, namely science, technology, engineering and mathematics so that standing wave material becomes more meaningful and enhance abilities related to the four aspects of STEM that an be trained for students.

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Development of hybrid learning design assisted by LMS sipda in modern physics course

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Abstract. *This study aimed to produce a feasible hybrid learning Modern Physics learning design assisted by LMS Sipda and to determine students' responses to the Modern Physics learning design. This learning design consists of 5 parts which include a) learning objectives and course outcomes, b) student characteristic sheets, initial ability questions, and prerequisites, c) material analysis, d) learning models, methods, strategies, and e) assessment. Learning design can solve learning problems, improve learning quality, or achieve certain learning objectives consisting of a series of activities to design learning materials/products, develop and evaluate designs to produce effective and efficient designs. The research was conducted at the Physics Department of State University of Medan. This type of research used the 4D model, namely Define, Design, Develop, and Disseminate. The data analysis technique used is qualitative data analysis by describing feasibility and response. Data collection tools in this study are using questionnaires, observation and documentation. The results of this study are: (a) the percentage of assessment scores from material experts is 77.66%, and the percentage of assessment scores from media experts is 86.1% (b) the percentage of response scores from student response is 67.68%.*

Keyword: learning design, hybrid learning, LMS sipda

Introduction

Modern physics is a branch of physics that studies the nature of matter and energy at the atomic scale and subatomic particles (much smaller than atoms). Modern Physics began to be developed in the 20th century because the formulations in Classical Physics are no longer able to explain or solve phenomena that occur in tiny matter. In learning modern physics, students encounter many difficulties in understanding it. According to Djamarah [1], learning difficulties are caused by learning disorders, threats, and obstacles so that they show results that can be observed by educators, society, and families. According to Hermayawati [2], to many factors that cause students to have learning difficulties, that learning difficulties are based on: (1) learning motivation, (2) intakes, (3) the role of lecturers and students in learning, (4) infrastructure, (5)

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material, and (6) learning environment. According to Dajamas [3], the low motivation, learning activities, and mastery of student concepts in Modern Physics courses need to be addressed immediately because this will have an impact on Advanced Physics courses.

Therefore, educators need to make learning designs. This learning design is made so that participants more easily understand the material and the tasks given by the educator. The design will be made in hybrid learning design, meaning that there will be face-to-face and online meetings. hybrid learning is a combination of distance learning activities and face-to-face learning methods. The media and learning design were developed using the Sipda LMS. According to Permana [4], online learning will be more effective if supported by good facilities. One of the vital tools in online learning is the Learning Management System (LMS). In the Modern Physics course, there will be 16 meetings. The features in Sipda are student attendance, learning media, evaluation, and six assignments namely routine assignments, critical book report (CBR), critical journal report (CJR), ideas engineering (RI), mini research (MR), and project work (PR). In Gultom, Sundara, and Fatwara [5], hybrid learning requires special methods related to the delivery of mixed/hybrid learning to improve the quality of learning as well as the role of universities in the implementation and delivery of material so that with mixed learning methods the material delivered can be thoroughly understood by students.

Learning design is a process carried out systematically to solve learning problems, improve learning quality, or achieve certain learning objectives consisting of a series of activities to design learning materials/products, develop and evaluate designs to produce effective and efficient designs. Learning design is seen as the same thing as learning development activities, it can be concluded that learning design is the practice of preparing models and media of communication technology and content to assist the process of transferring knowledge effectively between lecturers and students. This process involves determining the initial status of student understanding, formulating learning objectives, and designing model-based and media-based “treatments” to help the transition occur. According to Benny A. [6], the main components of learning design are: 1) learning objectives (general and specific) are the elaboration of competencies to be mastered by learners, 2) learners (the focus party) that need to be known include, their characteristics, initial abilities and pre-requisites, 3) learning analysis is the process of analyzing topics or materials to be learned, 4) learning strategies can be done macro in a period of one year or micro in a period of one teaching and learning activity, and 5) learning assessment about measuring abilities or competencies that have been mastered or not. The research objectives to be achieved in the study are: 1) to produce a feasible hybrid learning design assisted by LMS Sipda in Modern Physics, and 2) to determine student responses to hybrid learning design assisted by LMS Sipda in Modern Physics.

Methodology

This research was conducted at the Department of Physics Unimed. The research subjects are students of the class 2021 Dik B and class 2021 Dik C Modern Physics courses. This research uses the Research and Development (R & D) model developed by Thiagarajan, et al [7], namely define, design, development, and disseminate. Data analysis techniques are carried out using analytical techniques.

After all data has been obtained and collected, the data needs to be analyzed. Qualitative and quantitative data analysis techniques were used by researchers in this development. Quantitative

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data consists of assessment scores by material experts and media experts. The percentage of feasibility is presented in Table 1.

Table 1. Percentage scale

Percentage of Achievement	Scale	Interpretation Score
76% ≤ score ≤ 100%	4	Very Feasible
51% ≤ score ≤ 75%	3	Feasible
26% ≤ score ≤ 50%	2	Pretty Feasible
0% ≤ score ≤ 25% 1	1	Not Feasible

Research results and discussions

Research results

This research produces a product that is Modern Physics learning design, (a) the percentage of assessment scores for learning design from material experts is 87%, and the percentage of assessment scores from media experts is 76.33%, and (b) the percentage score of responses from student reviewers is 86%. Based on the development of the 4D development model used in this study, namely:

Define stages

This stage is an initial activity by conducting a needs analysis and literature study to determine the product to be developed. Researchers conducted a needs analysis through observations during the learning process of Modern Physics courses and interviews with lecturers who teach Modern Physics courses. The curriculum used is the KKNI 2020 curriculum (independent learning). Then, analyze the material based on learning objectives and learning outcomes. The learning objectives are to be able to know, understand, apply, and analyze the concepts of Modern Physics in a real context, and find solutions to problems related to the concepts of Modern Physics. This course is also expected to be able to improve Critical Thinking and Problem Solving through contextual questions related to Modern Physics Concepts. This course is also expected to be able to help students innovate and become a solution to problems related to the concepts of Modern Physics. There are eight learning outcomes of the course.

Design stages

This stage is an activity of designing the product to be developed. The design is carried out in the manufacture of Modern Physics learning design for modern physics courses. For learning design, a learning design guidebook is made, which contains components of learning design, namely a) learning objectives and outcomes, b) student characteristic sheets, questions of initial abilities and prerequisites, c) learning analysis, and d) strategies, models, and learning methods. Learning design is been made using Canva, the product is a Modern Physics Hybrid Learning design.

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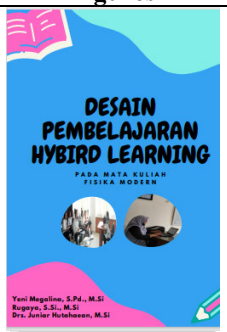
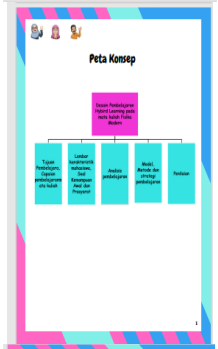
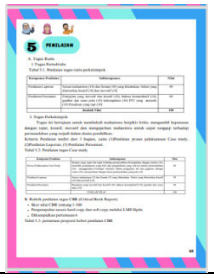
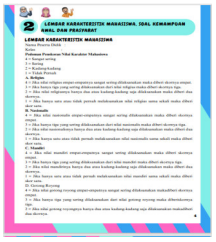
Table 2. Learning design products

No	Figures	Description	No	Figures	Description
1.		Cover of learning design	5.		Learning analysis
2.		Concept Maps are created to make it easier for lecturers and students to understand the learning design.	6.		Learning strategies consist of lecture method, case method, hybrid learning, project learning model, flipped blended learning model.
3.		Course outcomes and course objectives	7.		This assessment consists of routine tasks, CBR, CJR, idea engineering, mini research and project work.
4.		Student characteristics sheet, initial ability questions, and questions related to wave courses and mathematical physics.			

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The learning design is placed using the Sipda LMS, shown in the figure below:

Figure 1. Learning Design display on the LMS Sipda

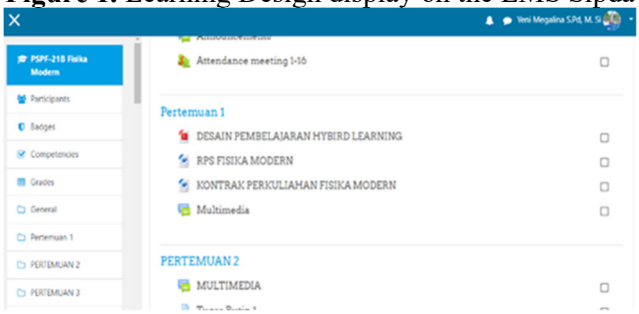

Figure 2. Learning Design display Using Sipda LMS

Develop stages

This stage is an activity of designing the product to be developed. The design is carried out in the manufacture of Modern Physics learning design for modern physics courses. For learning design, a learning design guidebook is made, which contains components of learning design, namely: a) learning objectives and outcomes, b) student characteristic sheets, questions of initial abilities and prerequisites, c) learning analysis, and d) strategies, models, and learning methods. Learning design is been made using Canva, the product is a Modern Physics Hybrid Learning design.

Table 3. Feasibility for material experts on learning design

No.	Aspects	Frequency					Score	Item	Max Score	Percentage
		1	2	3	4	5				
1	Software Usage	1	4	18	72	77	736	172	860	85.6
2	Learning design	0	2	46	159	132	1438	339	1695	84.8
3	Language	0	0	12	48	60	528	120	600	88
Total							**2702**	**631**	**3155**	**86.1 %**

Table 4. Results of media expert feasibility of learning design

No.	Aspects	Frequency					Score	Item	Max Score	Percentage
		1	2	3	4	5				
1	Software Usage	2	12	24	127	129	1251	294	2940	42.55
2	Learning design	0	6	10	103	77	839	196	980	85.61
3	Language	5	19	24	262	278	2553	588	2940	86.83
Total							**4643**	**808**	**6860**	**67.68 %**

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Table 5. Student response to learning design

No.	Aspects	Frequency					Score	Item	Max Score	Percentage
		1	2	3	4	5				
1	Learning Design	0	0	6	15	0	78	21	105	74
2	Graphics	0	0	0	8	2	42	10	50	84
3	Language	0	0	1	0	3	15	4	20	75
Total							**135**	**35**	**175**	**77.66%**

Disseminate stages

This stage is an activity to spread the learning design products that have been developed to be used by students and the user community. The distribution of this product is done by submitting multimedia products to lecturers who take Modern Physics courses.

Discussion

This stage is an activity to spread the learning design products that have been developed to be used by students and the user community. The distribution of this product is done by submitting multimedia products to lecturers who take Modern Physics courses.

The results showed that Hybrid learning design in general physics courses is very feasible to use. The development model uses Research and Development (R & D) Thiagarajan, et al [7], namely define, design, development, and disseminate. This learning design is made so that students can more easily understand the material, understand the tasks they want to do. Many students find it difficult to understand the material. According to Puspita Sari [8], Factors that influence difficulties in learning or understanding material are internal factors, namely students' reluctance to repeat learning material and lack of practice doing problems, and external factors, namely ineffective lecture time. Even though the COVID-19 pandemic has ended, online learning is still used at UNIMED. The hybrid learning design in this modern Physics course consists of a) learning objectives, course learning outcomes, b) student characteristic sheet, initial ability, and prerequisite questions, c) analysis of modern Physics learning materials: development of modern physics, theory of relativity, particle-wave dualism, atomic model and spectrum of the hydrogen atom, Schrodinger equation, d) learning strategy consists of learning model and learning method. The learning models used are project learning models, problem-based learning models, cooperative learning models, and flipped learning models. The methods used are the lecture method, discussion method, and case method, and e) assessment which consists of routine assignments, CBR, CJR, idea engineering, mini research, and project work. This assessment is equipped with an assignment assessment rubric so that students can actually assume what value the lecturer will give. According to Hilda Taba in Meriyati [9], learning design at least considers the following components of learning cycles: (1) learning objectives/competencies, (2) teaching materials, (3) approaches/ methods/strategies, and (4) assessment.

This hybrid learning design is produced through a laptop by using several applications, namely Word, PowerPoint, Cap Cut, and Canva. Word is used to write Canva is used to make the cover of the hybrid learning design guidebook more attractive. The results of Monoarfa & Haling's research [10] Using the Canva application, teachers can teach knowledge, creativity, and skills that will be obtained for students, so that this media can also be utilized in various domains of life. Microsoft PowerPoint to present and position text, graphics, video, and sound.

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Then there is the Cap Cut application, which is an editing application that has many interesting features.

After the learning design is made, it is assessed by material and media experts to see the feasibility of a hybrid learning model learning design in modern physics courses. The feasibility questionnaire for media experts has 3 aspects, namely aspects of software usage, learning design, and language. The results of this media expert assessment in terms of aspects: (1) software usage scored 736 (85.6%), (2) learning design scored 1438 (84.8%), and (3) language scored 528 (88%). Overall the media validation level obtained a score of 2702 (86.1%). Based on the feasibility questionnaire by material experts covering 3 aspects, namely learning design, graphics, and language. Data on the results of feasibility by material experts in terms of (1) learning design which obtained a score of 78 (74%), (2) graphics obtained a score of 42 (84%), and (3) language 15 (75%). Overall the material validation level obtained a score of 135 (77.66%). Based on the student response to learning design covering 3 aspects, namely software usage, language, and learning design. Data on the results of student response in terms of (1) software usage which obtained a score of 1251 (42.55%), (2) language obtained a score of 839 (85.61%), and (3) learning design 2553 (86.83%). Overall the material validation level obtained a score of 4643 (67.68%).

Feedback from this learning design is a) the learning outcomes in this document only cover the realm of C3 (application), while the learning objectives are in the realm of C4 (analysis) and HOTS (critical thinking and problem solving), b) some concepts that should be added to study are Elementary Particles, such as Quarks to broaden students' insights in physics, c) learning outcomes should be adjusted to learning objectives, d)need to explain in more detail about what cases will be studied in lectures for case studies, e) based on the assessment results and responses from students obtained from the questionnaire, the physics learning design is very feasible to use, f) learning objectives are in accordance with the learning outcomes, g) in the new case study it must be clear what to do, and i) the concept deepening needs to be expanded for advanced courses.

Conclusion

The resulting product is a Hybrid Learning Design in Modern Physics course. This Learning Design consists of (a) learning objectives, learning outcomes, (b) student characteristic sheets, questions of initial abilities and prerequisites, (c) learning analysis, (d) learning models, methods, and strategies, and (e) assessment. This learning design is placed on the Sipda LMS. The results of the feasibility are (a) the percentage score of the material expert assessment is 77.66%, the percentage score of the media expert assessment is 86.1%, and (b) the percentage score of responses from student response is 67.68%.

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Edge detection for cracks in building concrete structures using the canny algorithm

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Abstract. *In image processing, edge detection is a stage that has an important and significant role. From a computational point of view, the Canny algorithm produces a high level of precision. In using the Canny algorithm, a Gaussian filter is applied to filter out noise in the image. This algorithm is applied to images of cracks in building structures. By using this algorithm, a high level of edge detection accuracy is obtained. In addition, with the application of this algorithm, the results show that the application of the algorithm can overcome noise in the image, provide very precise edge detection, and clarify the location of cracks in the building structure.*

Keywords : edge detection, canny algorithm, gaussian, image processing, structure, cracks

Introduction

In building structures, there are often indications of mechanical component failure. One indication can be seen in the presence of cracks in the building structure. Cracks can occur due to internal factors such as inappropriate mixtures, improper installation techniques, and the influence of the mass of the building structure [1]. In addition, cracks can occur due to external factors such as earthquake lateral loads, thermal expansion from the environment, and lack of maintenance of the building [2–4].

Cracks in concrete structures in buildings are often ignored. Even though cracks in concrete structures will have a fatal impact over a certain period of time, Cracks are very basic damage to concrete structures [5]. Cracks can cause the ability of the structure to withstand loads to

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decrease [6]. The presence of cracks can also reduce the stiffness of building structural elements [7,8]. The most fatal are construction failures and disasters [9]. The possibility of material loss and loss of life will be greater.

It is necessary to identify cracks in building structures early. One way to identify it is through images. Edge detection is one of the methods that can be used to identify objects through images. Edge detection has an important role in image processing. By using edge detection, a lot of information can be obtained. These include object recognition [9–12], face recognition [13–15], image mapping [16,17], medical image processing [18–21], and image processing in engineering [22,23]. In this paper, we would like to demonstrate edge detection on concrete crack images of building structures. In the process, we use the Canny algorithm for edge detection of the processed image.

Canny edge detection algorithm

The Canny edge detection algorithm is one of the most widely used methods for digital image edge detection. This algorithm is a series of processes designed to accurately identify the edges of an image. It can also minimise the impact of noise [24–27]. Because of these capabilities, this algorithm is widely used in various applications such as computer vision [28–32], image processing [33,34], and feature extraction [24]. Image processing using this is done by combining the image smoothing process using a Gaussian filter, gradient calculation, non-maximum suppression, and edge tracking with hysteresis to achieve this [35–37].

Image preprocessing

Preprocessing is the first part of the Canny algorithm. This is because the detection results are very sensitive to noise. Input image preprocessing is done to reduce noise. The niose reduction process is done using a Gaussian filter [38,39]. The Gaussian filter works by blurring the image slightly by converting the image to grey scale [40,41]. The contrast and brightness levels of the image are adjusted as the noise decreases or even disappears. This process is very important to improve the accuracy of the edge detection process. The Gaussian filter in 2-D is affected by the deviation of the Gaussian distribution with y distance on the vertical axis and x distance on the horizontal axis [24]. So, the Gaussian filter can be expressed as

$$G(x.y) = \frac{1}{2\pi\sigma^2} exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \quad (1)$$

Gradient calculation

After the image smoothing process, the next step is gradient calculation. In this case, the gradient is the rate of change of image pixel intensity [42,43]. The gradient computation using the Canny edge detection operator will detect the edge intensity and direction [44,45]. The edge intensity and direction here are in different directions. The magnitude and direction of the gradient at each pixel are calculated. The magnitude represents the edge strength and the direction indicates the edge orientation. Relative to direction, the gradient in this case is a unit vector. In the calculation process, the vertical and horizontal parts of the gradient are calculated, as well as the magnitude and orientation of the gradient. To calculate the gradient (G), the equation

$$G = \sqrt{G_x^2 + G_y^2} \quad (2)$$

As for calculating the gradient angle, it can be calculated by

$$\theta = are\ \tan\left(\frac{G_y}{G_x}\right) \quad (3)$$

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Non-maximum suppression

Non-maximum presses are an important step in Canny's algorithm for thinning edges. This involves scanning the image with gradient magnitudes and ensuring that only local maximums are retained as potential edge pixels. For each pixel in the magnitude gradient image, non-maximal emphasis compares the magnitude of the gradient to the magnitude of its neighbors in the direction of the gradient. If the current pixel size is maximum in that direction, it is considered an edge candidate. Otherwise, it will be pressed (set to zero).

Edge tracking by hysteresis

After unmaximal suppression, there are still some isolated edge points. To form a continuous edge contour, a technique called edge tracking with hysteresis is applied. This involves setting two threshold values, namely a high threshold (T_{high}) and a low threshold (T_{low}). Pixels with a gradient magnitude above T_{high} are considered strong edge points, while pixels between T_{low} and T_{high} are considered weak edge points [46]. The algorithm then connects the strong edge pixels to the neighbouring weak edge pixels, creating a continuous edge. This is usually done using techniques such as edge bridging and connectivity analysis.

Thresholding

The selection of threshold values (T_{high} and T_{low}) is very important and depends on the specific application and image characteristics. Setting these thresholds appropriately can significantly affect the quality of edge detection. Choosing a high threshold value will result in a more rigorous edge detection process and produce only strong edges [47]. A lower value will result in more edges being detected, including weaker and potentially noisy edges.

Results and discussions

The image processing process begins with removing potential noise from the image. The concrete crack image was used with dimensions of 2711x2500 (width 2711 pixels and height 2500 pixels) and bit depth 8.

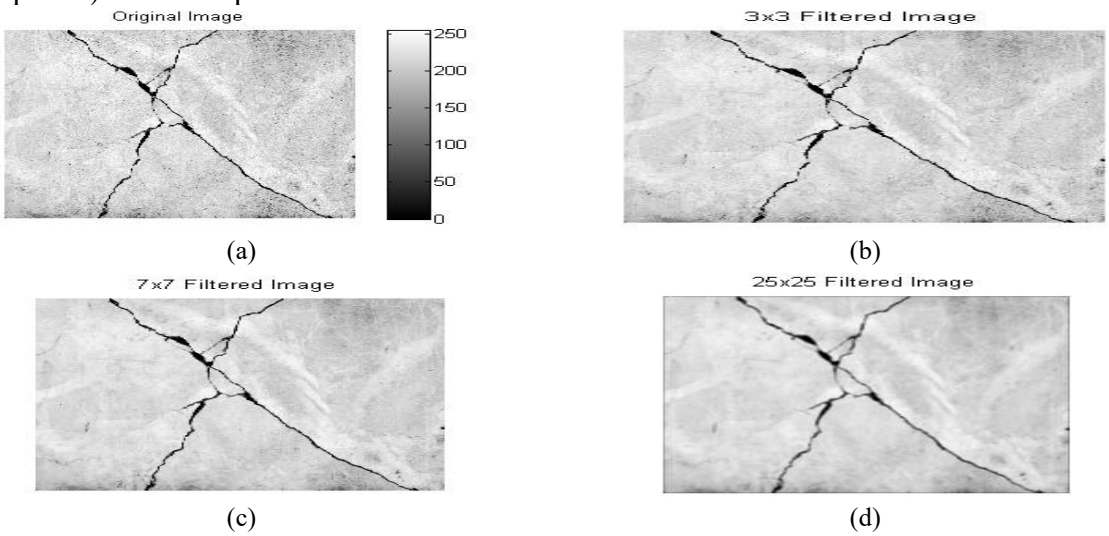

Figure 1. Removing potential noise from images. (a) Original image, (b) Image with 3x3 filter, (c) Image with 7x7 filter, (d) Image with 25x25 filter.

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From Figure 1 (a), the original simulated image can be seen. Furthermore, in Figure 1 (b), noise removal has been carried out using a Gaussian filter with a 3x3 filtered image. The noise removal process continues with a 7x7 filtered image, as shown in Figure 1 (c). The noise removal process stops at a 25x25 filtered image, as shown in figure 1 (d). At 25x25, the filtered image has disappeared entirely, so that the resulting image becomes more blurry.

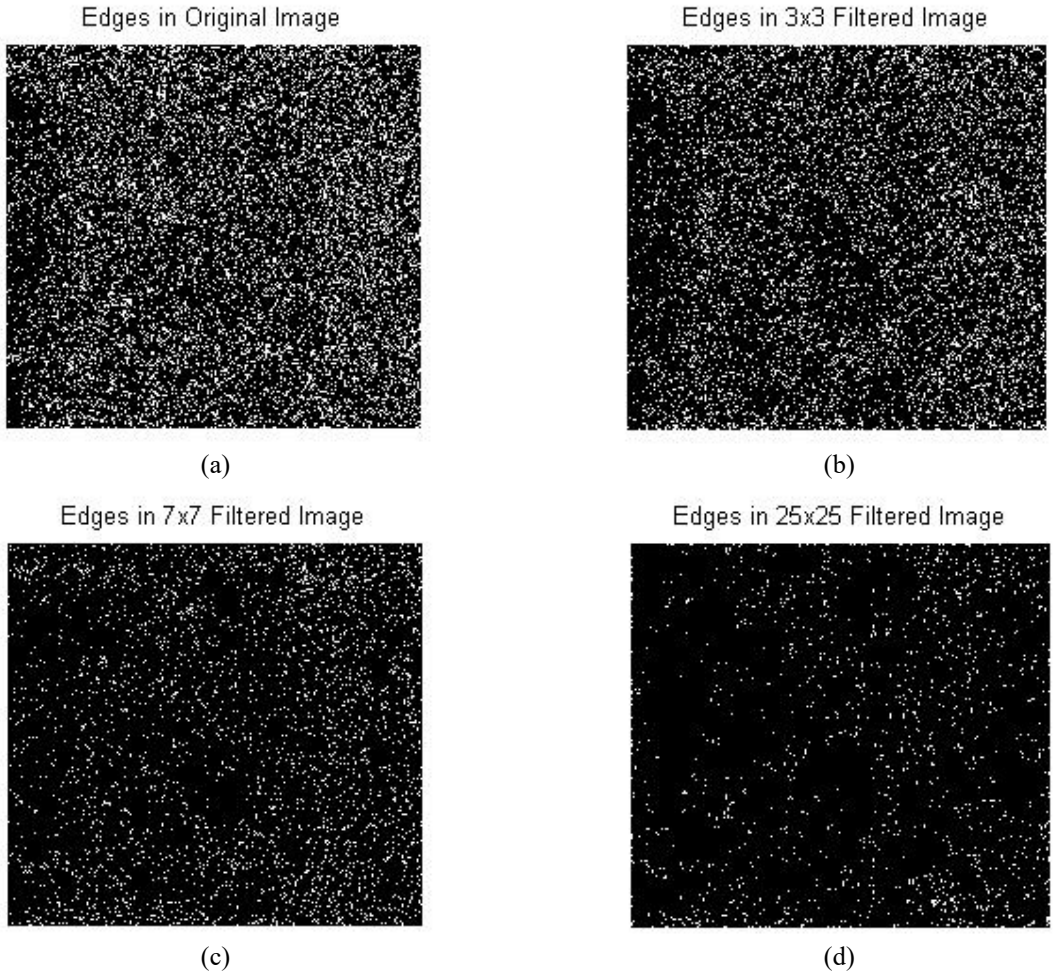

Figure 2. Detecting Edges in Images. (a) Original image, (b) Image with 3x3 filter, (c) Image with 7x7 filter, (d) Image with 25x25 filter.

The next process is the edge detection process of the image. The edge detection process is carried out using three times the filter. Figure 2 (b) shows the edge detection result using 3x3 filtered image. In this condition there are still many image edge points detected. Furthermore, 7x7 filtered image and 25x25 filtered image are performed as shown in Figure 2 (c) and 2 (d). The higher the filter, the more detailed the image edge points obtained.

In the final stage, a thresholding process is performed on the image. This process is to detail the detection performed. At this stage, three filters are also performed as shown in Figure 3 below.

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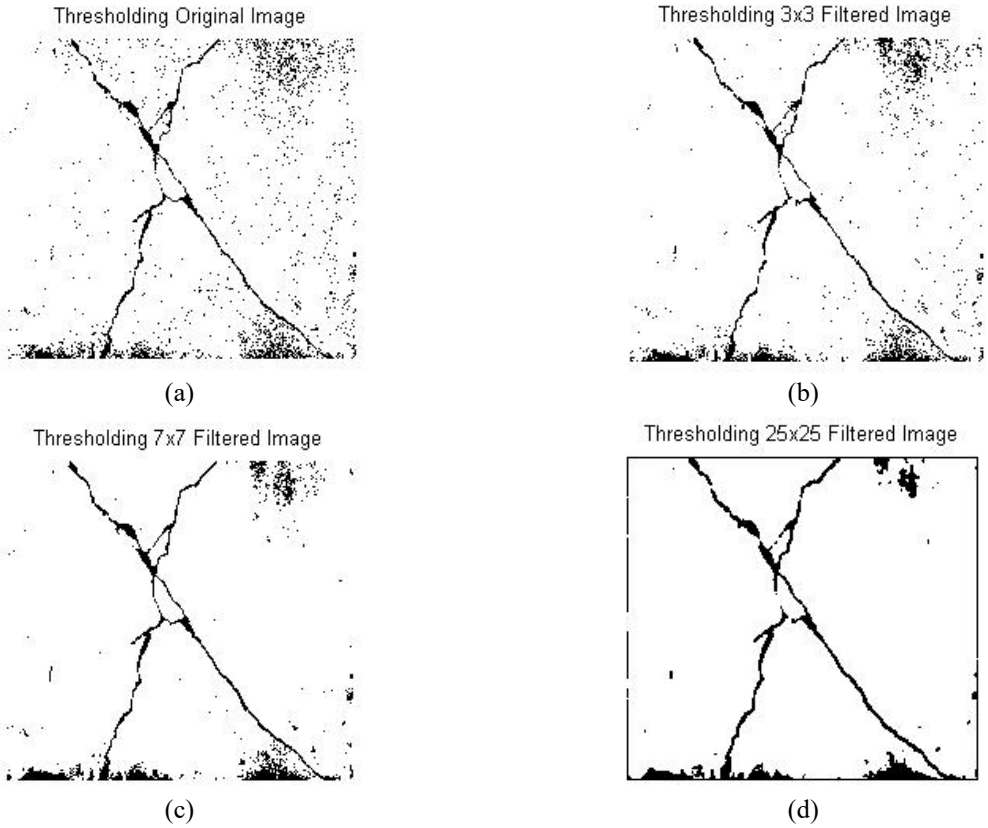

Figure 3. Creating Binary Images by Thresholding. (a) Original image, (b) Image with 3x3 filter, (c) Image with 7x7 filter, (d) Image with 25x25 filter.

Figure 3 (b) shows the result of thresholding 3x3 filtered image. The results of crack detection in concrete are more clearly visible. Furthermore, thresholding 7x7 filtered image as shown in Figure 3 (c). In this filter, the edge points other than the edge points of the concrete cracks are reduced. The image thresholding process stops at thresholding 25x25 filtered image. In this result the detection of cracks in concrete is very clear. The cracks are indicated by black lines as shown in Figure 3 (d). In this thresholding process the background of the image is removed completely. This background removal helps to clarify the edge points of the cracks.

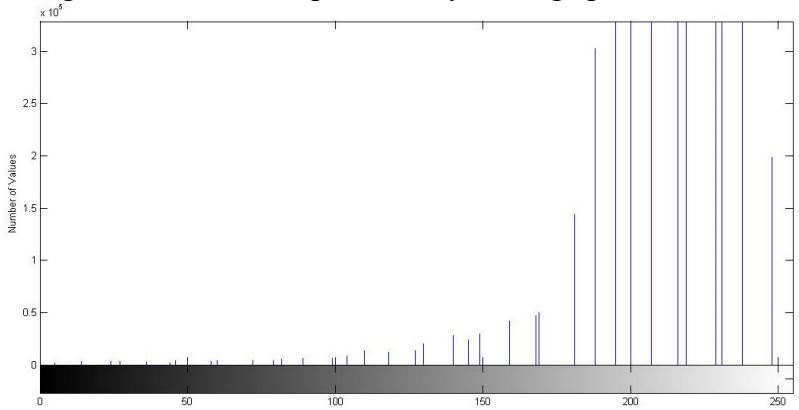

Figure 4. Histogram of Original Image.

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The histogram of the original image indicates how many times each intensity value was used. This histogram can be viewed to determine a good threshold for creating a binary image. The histogram of the original image of cracks in concrete is shown in Figure 4. Based on the histogram obtained, it can be seen that initially the stability of the original image is quite low. By going through the edge detection process using the Canny algorithm, the image stability level is getting higher and better.

Conclusion

Image processing provides an opportunity to get more information from an object. The use of Canny edge detection algorithm greatly facilitates image processing. With the help of this algorithm the noise in the simulated concrete crack image can be removed. This noise removal process is very helpful to detect and clarify the cracks. From the above study, it is seen that edge detection using Canny edge detection algorithm is capable of detecting concrete cracks. This is reinforced by the results obtained especially after the thresholding process. From the thresholding process, a very clear image of the crack is obtained which leaves the image of the crack. Based on the simulation results, there are some inputs for further research. The quality of the original image used for edge detection should be tested with better image quality. In addition, further edge detection can be done with other methods to be able to compare the results obtained.

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Comparative study of concrete mix materials on the response of multi-storey building structures using the finite element method

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Abstract. *The search for new materials for concrete mixes continues. The expected materials are those that increase the strength of concrete and are non-emitting. In this study, three concrete mix materials were compared. Concrete mixtures of fly ash, silica fume and liquid CO_2 in multi-storey building structures subjected to earthquake lateral loads were analysed for their response. The analyses were performed by numerical calculations using the finite element method (FEM). The numerical calculations performed produced the sway patterns, eigenvalues, circle frequency,*

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frequency, and period of the building structure. So that the best material is obtained which will be used as a reference in finding new concrete mix materials.

Keywords : material, structure, earthquake, FEM, mode shape, displacement, shear force

Introduction

Innovation in building design and structure continues to grow. In the design section, modifications continue to be made to beautify the building. Meanwhile, the building structure continues to be developed to obtain a strong and profitable building structure [1,2]. Strong here in the sense that the structure can withstand external influences that can affect the durability of the building [3]. These external influences such as wind [4–6], temperature [7], and earthquake lateral loads [8–11]. These natural conditions become one of the most important considerations, especially in multi-storey buildings.

This study discusses the effect of earthquakes on multi-storey building structures. The interaction between plates causes vibrations [11]. This interaction also causes the release of seismic energy that causes deformation of tectonic plates [12,13]. This condition causes the lateral load of an earthquake. This lateral load will be felt by all objects on the earth's surface within a certain radius [14]. Buildings within that radius are no exception. In some cases, the earthquake lateral loads felt by building structures have a negative impact.

There are many impacts of earthquakes on building structures. In general, lateral loads generated by earthquakes will cause movement in multi-storey building structures [15]. Greater impacts are likely to occur following the movement of multi-storey building structures. The most minor impact is the appearance of cracks in multi-storey building structures [16,17]. Even worse, it can lead to a greater impact, namely the collapse of multi-storey buildings [18,19]. This condition will cause greater losses. Therefore, in this paper, a preliminary analysis of several concrete mix materials was conducted [20]. The concrete mix materials used are fly-ash, silica fume, and liquid CO_2. With the help of computational calculations, the best concrete mix for multi-storey buildings will be analysed.

Building structure response

Structural dynamics plays an important role in analysing the structural response of buildings. Newton's 2nd law is the foundation for its development. Especially when studying the structural response of buildings during earthquakes. The lateral force of the earthquake makes it even more influential. Multi-storey buildings are often approached with the concept of Multi Degree of Freedom (MDOF) [21,22]. MDOF will be approached with Newton's 2nd law approach. The physical approach continues to be used in designing physical models of multi-storey building structures. Multi-storey buildings are modelled as spring systems [23,24]. This system is composed of objects, springs, and dampers [25,26]. The foundation of the building makes the spring system with one end of the system isolated. This system is shown as in Figure 1.

From the designed physical model, the influential parameters are obtained. These parameters are mass (m), spring constant (k), and damping (c). The acceleration of the earthquake makes the force (F) that works can be calculated [27]. Mathematically, this condition can be expressed by

$$m\ddot{x} + c\dot{x} + kx = m\ddot{x}_g \quad (1)$$

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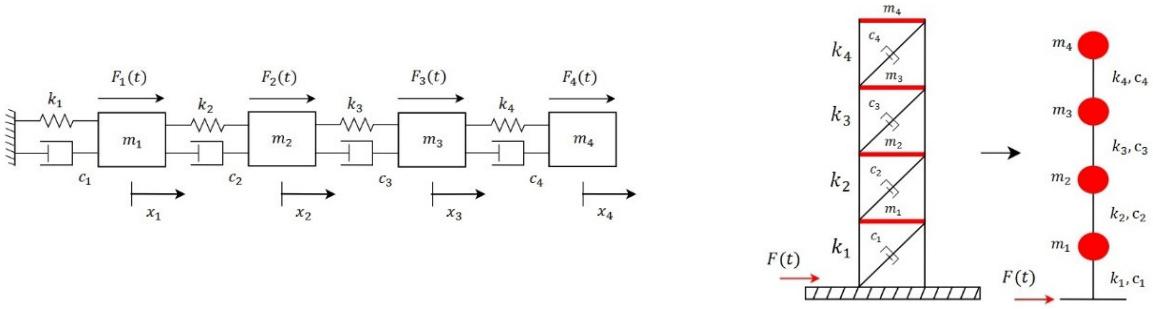

(a) (b)

Figure 1. The physical model. (a) Spring-damped system; (b) MDOF system.

In equation 1, the ground acceleration due to earthquake is symbolised by x¨_g. Thus the acting force F and the respective motion parameters acting in the MDOF system can be expressed by [27–29].

$$F_m = m_1\ddot{x}_1 + m_2\ddot{x}_2 + \cdots + m_n\ddot{x}_n \quad (2)$$

$$F_c = c_1\dot{x}_1 + c_2\dot{x}_2 + \cdots + c_n\dot{x}_n \quad (3)$$

$$F_s = k_1x_1 + k_2x_2 + \cdots + k_nx_n \quad (4)$$

So equation 1 can be expressed in matrix form.

$$-M\ddot{x_g}(t) = M\ddot{x}(t) + C\dot{x}(t) + Kx(t) \quad (5)$$

Earthquake lateral loads that become external forces result in inertial forces acting on multi-storey buildings. So that the external force acting becomes [30]

$$F(t) = -MIx_g\ddot{(}t) \quad (6)$$

Thus equation 5 is expressed by

$$-MI\ddot{x_g}(t) = M\ddot{x}(t) + C\dot{x}(t) + Kx(t) \quad (7)$$

A computational approach is used to simplify the analysis process. In this case, the finite element method is utilised to obtain more precise results. The numerical calculation process follows the flowchart below.

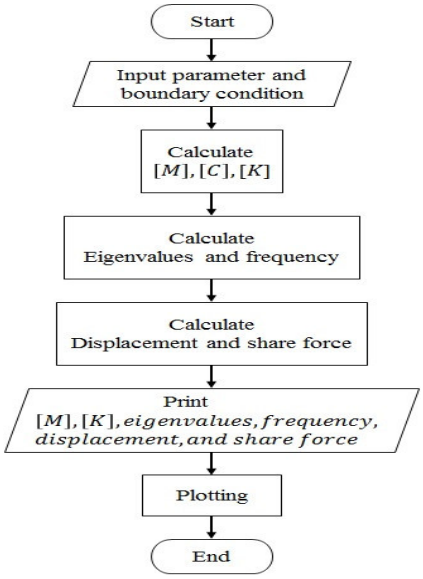

Figure 2. Flowchart of numerical calculations.

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Results and discussion

In the first part, the structural response of the multi-storey building was analysed through the impact of the earthquake lateral load on the structural motion. This impact can be seen from the mode shapes of the multi-storey building structure obtained. The number of mode shapes obtained is proportional to the number of floors of the multi-storey building being simulated. In this case, a four-storey building was simulated, resulting in four mode shapes. A comparison of the mode shapes for each concrete mix is shown in Figure 3, Figure 4, and Figure 5.

Based on Figure 3, Figure 4, and Figure 5, the sway patterns are almost the same. In each mode shape 1 shows that the lower part of the multi-storey building moves in the direction of the external force. While the top of the building moves in the opposite direction to the incidence of external forces. This condition is caused by the direct interaction of the multi-storey building foundation with the incident external force. In addition, increasing the acceleration value can increase the deviation between floors [31].

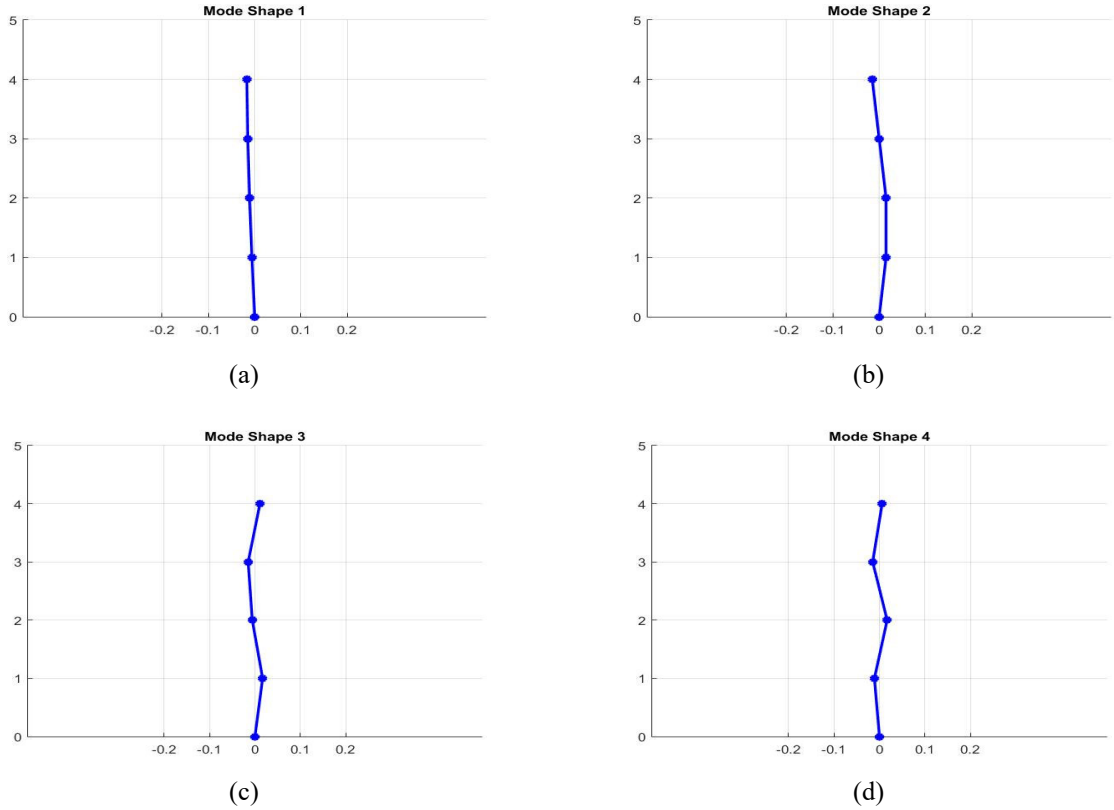

Figure 3. Mode shapes of a multi-storey building with fly-ash mixed concrete. (a) Mode shape 1, (b) Mode shape 2, (c) Mode shape 3, (d) Mode shape 4.

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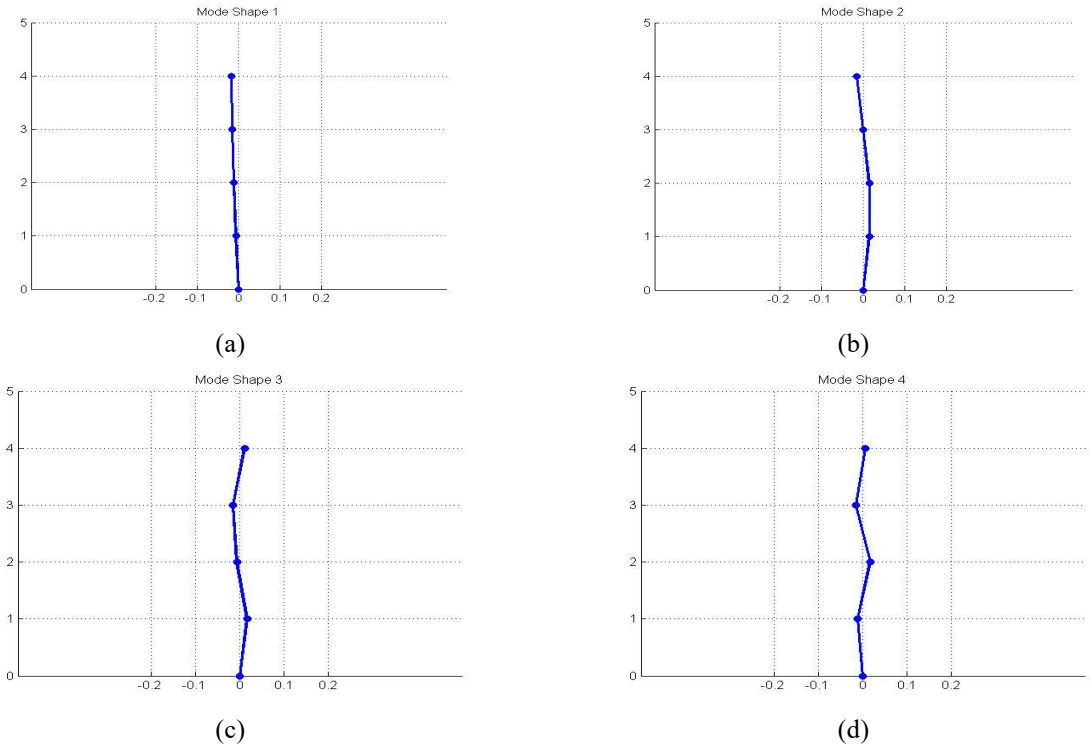

Figure 4. Mode shapes of a multi-storey building with silica fume mixed concrete. (a) Mode shape 1, (b) Mode shape 2, (c) Mode shape 3, (d) Mode shape 4.

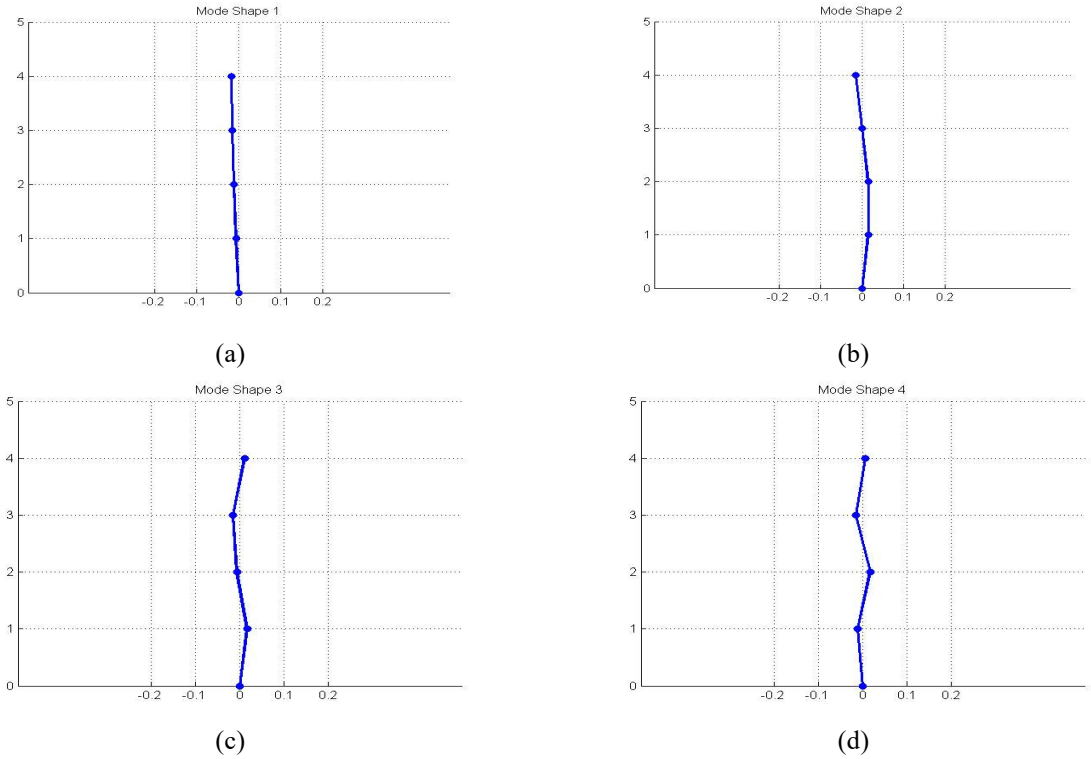

Figure 5. Mode shapes of a multi-storey building with CO_2 liquid mixed concrete. (a) Mode shape 1, (b) Mode shape 2, (c) Mode shape 3, (d) Mode shape 4.

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The structural response of the multi-storey building is then analysed through eigenvalues, circle frequency, frequency, and period respectively. The value of each parameter is seen from each mode shape obtained. The simulation results show the comparison of the eigenvalues obtained as shown in Figure 6.

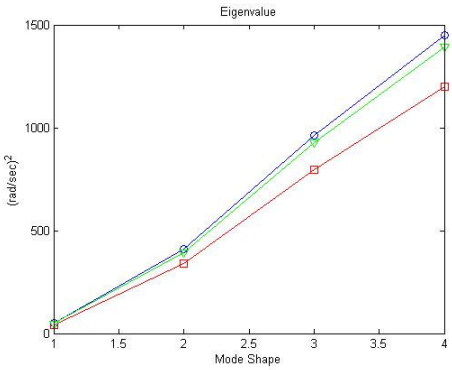
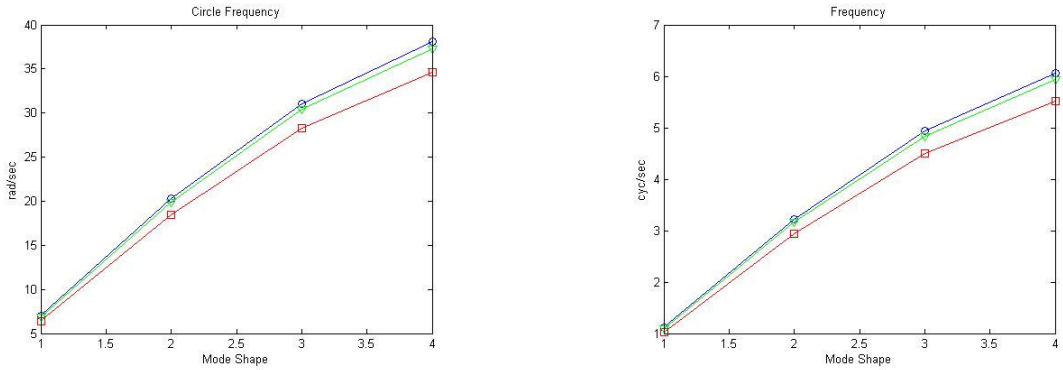


Figure 6. Comparison of structural responses of high-rise buildings with fly-ash, silica fume, and CO_2 liquid concrete mixtures based on eigenvalues.

Next is the frequency of multi-storey building structures during earthquakes. The frequency of multi-storey buildings is influenced by the lateral frequency. This lateral frequency is the frequency generated by the earthquake that occurred. A comparison of the frequencies obtained is shown in Figure 7.



(a) (b)

Figure 7. Comparison of structural response of multi-storey building with fly-ash, silica fume, and CO_2 liquid concrete mixtures based on circle frecuency and frequency.

Meanwhile, the period obtained is shown in Figure 8. From Figure 5-8 the red line shows the value of fly-ash mixed concrete, blue shows the value of silica fume mixed concrete, and green shows the value of CO_2 liquid mixed concrete. For eigenvalue, circle frequency, and frequency from mode shape 1 to mode shape 4 the value increases. It is inversely proportional to the period value which is decreasing. Based on the above results, it is obtained that concrete with fly-ash mixture has a smaller frequency shift. A smaller frequency shift can indicate a safer building [32,33]. It can also be stated that multi-storey buildings with such concrete mixtures are less likely to experience damage.

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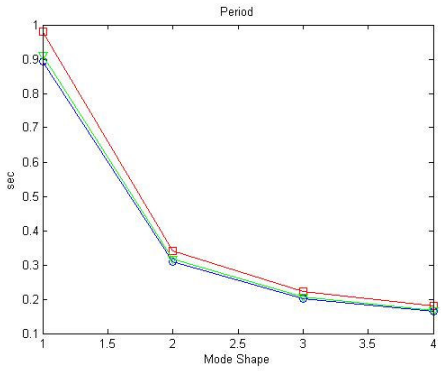

Figure 8. Comparison of structural response of multi-storey building with fly-ash, silica fume, and CO_2 liquid concrete mixtures based on period.

Conclusion

A computational approach was taken to determine the structural response of a multi-storey building. The finite element method was used to simulate the four-storey building. This method is used to obtain more accurate results. In this study, the structural response of multi-storey buildings was analysed through mode shapes, eigenvalues, circle frequency, frequency, and period. Three simulations were conducted with different concrete mixtures. The first simulation was conducted with fly-ash concrete mix. Then simulations were conducted with silica fume concrete mix and liquid CO_2 concrete mix. The simulation results show that the three types of materials produce almost identical mode shapes. Different results were obtained in the values of eigenvalues, circle frequency, frequency, and period. The values of eigenvalues, circle frequency, and frequency tend to increase from mode shape 1 to mode shape 4. On the other hand, the period value decreases. Based on the frequency values obtained from the simulation, it can be concluded that fly-ash mixed concrete has a smaller risk of damage. To obtain more detailed information, future research can analyse the displacement and shear force values of multi-storey building structures during earthquakes, so that one material can be used as a reference for the development stage.

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Composition of fishermen's catch using gill nets in Bagan Serdang, Deli Serdang Regency, North Sumatra Province, Indonesia

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Abstract. *This research aims to inventory the species of fish caught by fishermen using gill nets and classify them based on their conservation status. The research was conducted from 11-13 August 2023 in Bagan Serdang, Deli Serdang Regency, North Sumatra, Indonesia. This research uses the census method to collect fish data. Data analysis was carried out descriptively. The research results showed that there were 18 species, 14 families and 4 orders of fish that had been identified. The most dominant of fish species is the Carangidae family with four species. Calcification based on fish conservation status shows 15 species (83%) in the LC category (Least Concern), 1 species EN category (5.5%), 1 species NT category (5.5%), and 1 species DD category (5.5%).*

Keywords: inventory, species, fish, carangidae

Introduction

The production of fishery products in Indonesian waters is recorded to be relatively diverse [1]. Fishermen have used these fishery products as their main source of income because they have economic value [2]. One of the regencies that has potential in the fisheries sector is Deli Serdang, where this district is located in a coastal area so it directly faces the sea [3-4]. In this regency, capture fisheries activities are carried out in several districts such as Labuhan Deli, Hamparan Perak, Pantai Labu and Percut Sei Tuan. The highest capture fisheries production in this district is in Pantai Labu, so it is important to carry out studies as an effort to use sustainable fisheries.

The center of capture fisheries activity in the Pantai Labu district is in Bagan Serdang, where fisheries production in this area reached 51,741.48 tonnes in 2015, including 46,299.65 tonnes of capture fisheries products and 5,300.13 tonnes of other fisheries products [5]. Therefore, most of the people living in the village work as fishermen.

Fishermen catch fish almost every day using gill nets in Bagan Serdang. This type of net is usually used to catch pelagic and demercial fish [6]. Pelagic fish are a group of fish that are active on the sea surface [7], while demersal fish are active on the seabed [8].

Fishing activities continue to be carried out in the sea waters of the Bagan Serdang area, but unfortunately information about the species of fish has never been reported. Therefore, an inventory of fish species needs to be carried out for the purpose of monitoring threatened, economically important fish and the condition of fish in wild through fish composition and conservation status. It is hoped that the results of this study can be used as a reference for formulating policies regarding the sustainable use of fisheries in Pantai Labu, Deli Serdang Regency.

Methodology

This research was carried out directly in Bagan Serdang, Pantai Labu District from 11-13 August 2023. Sampling in this study used the census method [9], which recorded all species of fish caught by fishermen in Bagan Serdang who used gill net. Fish catches are classified based on their conservation status guided by the IUCN Red List of Threatened Species (https://www.iucnredlist.org/). The data that has been analyzed is then shown in tabulations and graphs and explained descriptively [10].

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Results and discussion

This research identified 18 species from 14 families, where Carangidae family is the group with the largest number of species (4 species). Carangidae is an exotic species, migrant from the sea and most commonly found in estuaries, both in tropical and subtropical areas [11].

Table 1. Taxonomic classification, local name and conservation status of fish caught in Bagan Serdang

Ordo/Family/Species	Local Name	Status Conservation (IUCN)	Average Value of Total Length (cm)	Average Value of Body Weight (g)
PERCIFORMES				
Scombridae				
Rastrelliger kanagurta	Kembung Kuring	DD	20	200
Scomberomorus commersoni	Tenggiri	NT	35	200
Terapontidae				
Terapon jarbua	Kerong-Kerong	LC	27	300
Sphyraenidae				
Sphyraena barracuda	Cincamin	LC	35	180
Carangidae				
Alepes djedaba	Selar	LC	20	200
Atropus atropos	Alu-Alu	LC	20	200
Megalaspis cordyla	Tegang Ekor	LC	25	200
Alepes melanoptera	Gelek	LC	23	200
Latidae				
Lates calcarifer	Peco	LC	30	400
Rachycentridae				
Rachycentron canadum	Gabus	LC	21	100
Eleutheronema tetradactylum	Senangin	EN	25	200
Priacanthidae				
Priacanthus macracanthus	Swanggi	LC	15.5	100
Lutjanidae				
Pinjalo pinjalo	Pucat	LC	15	50
BELONIFORMES				
Belonidae				
Tylosurus crocodilus	Bana	LC	60	460
CLUPEIFORMES				
Engraulidae				
Thryssa dussumieri	Kasai	LC	16	150
Scombridae				
Chirocentrus dorab	Parang	LC	35	100
PLEURONECTIFORMES				
Pleuronectidae				
Platichthyes flesus	Sebelah	LC	17	200
Cynoglossidae				
Cynoglossus lingua	Lidah	LC	17.5	40

Description: DD (Data Deficient), NT (Near Threatened), LC (Least Concern), and EN (Endangered)

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Based on the IUCN red list, commercial marine fish on the Bagan Serdang is dominated by the LC category (83%, 15 species), followed by the EN category (5.5%, species), the NT category (5.5%, 1 species) and the DD category (5.5 %, 1 species). The results on the conservation status of fish show that the fish identified are classified as Least Concern (LC), which means they have a low risk of extinction [12]. Fish are classified as Data Deficient (DD) which indicates a lack of available data [13]. The fish is classified as Endangered (EN), which indicates an emergency situation [14]. Fish classified as Near Threatened (NT) indicates a near threatened condition [15].

The dominance of LC on fish conservation status indicates a lack of information regarding fish ecology in the region. However, although this species of fish does not require additional protection, sustainable management practices are still necessary [16]. Excessive fishing or overfishing not only disrupts the structure of fish populations, but also causes ecosystem imbalance [17].

Based on this research, it shows that generally the fish caught are fish whose populations are still stable, except for two species, namely *Eleutheronema tetradactylum* and *Scomberomorus commersoni*. The EN status of *E. tetradactylum* shows that fish requires attention and conservation efforts. This is because the population has continued to decline over several decades. This condition is the result of intensive fishing without limiting the number of catches, spawning season and destructive fishing gear [18]. Furthermore, the NT status of *S. commersoni* shows that the fish population continues to decline, so that if there are no efforts to limit catch, the fish will be threatened with extinction in the next few years. Therefore, capture management is needed for this species so that it can be used sustainably [19].

Conclusion

This research shows that there are 18 species, 14 families and 4 orders of fish that have been identified. The most dominant type of fish is the Carangidae family with four species. Calcification based on fish conservation status shows 15 species (83%) in the LC category (Least Concern), 1 species EN category (5.5%), 1 species NT category (5.5%), and 1 species DD category (5.5%).

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Development of a science literacy assessment book for junior high school students: the feasibility based on classical test analysis and expert judgment

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Abstract. *The low level of scientific literacy ability of students in Indonesia is due to their lack of training in solving problems by applying scientific concepts. The development of this book was hoped that will become a guide for teachers and students to improve students' scientific literacy skills in Indonesia. The purposed of this research was to develop a proper science literacy assessment book based on classical test analysis, material experts, media experts, and assessment experts so that this book can be used in learning assessments to see the scientific literacy abilities of junior high school students. This research method was a 4D development method. This research focuses on preparing questions for scientific literacy tests based on Indonesian ethnoscience before they are made into book form. The sample of this study consisted of 437 junior high school students. This research involved 5 science education lecturers, 6 science teachers in validating the construct. The question book developed was a multiple-choice question consisting of 150 questions divided into 50 scientific literacy questions for 7th grade students, 50 scientific literacy questions for 8th grade students, and 50 scientific literacy questions for 9th grade students. Based on all measurements of the quality of the test measuring instruments were taken into consideration in developing ethnoscience-based scientific literacy test questions in Indonesia for junior high school students so that a total of 140 test questions were obtained that were valid, reliable and had a good difficulty index and discrimination index.*

Keywords: Science, Literacy, Assessment, Book, Feasibility

Introduction

The problem of the low scientific literacy achievements of Indonesian students involved in international research conducted by the Program for International Student Assessment (PISA) appears to be never ending. Indonesia has been involved in this study for two decades, but has

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never shown satisfactory results in the fields of mathematics, language, science and other literacy. The achievements of Indonesian students on scientific literacy over the last twenty years can be seen in the table 1 [1,2,3,4].

Table 1. Summary of Indonesian students' scientific literacy achievements in PISA

PISA Study Year	Average Grade/ PISA Standard (500)	Ranking
2000	360	40 out of 50 Countries
2003	370	39 out of 40 Countries
2009	383	57 out of 65 Countries
2012	382	64 out of 65 Countries
2015	403	65 out of 73 Countries
2018	396	70 out of 78 Countries

Based on the data above obtained from the OECD website, it is clear that Indonesia has never reached the average standards set by PISA. Of course, this fact is a focus for the government and especially for researchers in the fields of education and science. This is of concern to the government because a student's scientific literacy ability influences the quality of individuals or human resources in Indonesia in the future and of course this also has implications for the economic progress of a nation. A student is said to have scientific literacy abilities when they can solve the problems, they face in everyday life by applying the scientific knowledge they acquire at school and from the environment in general. Of course, this problem cannot be left alone. Researchers in the field of education throughout the world, especially in Indonesia, have done a lot of research and discussion regarding scientific literacy. The research that has been carried out has covered various aspects of learning and has even prepared prospective science teachers to have scientific literacy skills so that it can be ensured that prospective science teachers have scientific literacy skills to be distributed to their students, as in the example of research that has been carried out by the author itself, namely the application of scientific literacy aspects of the PISA 2015 framework in English for science lectures through lesson study which shows that scientific literacy aspects can be included in lectures by designing semester lecture plans so that they can instill a scientific literacy attitude towards prospective science teacher [5]. Apart from that, the author has also conducted research on the development of measuring instruments for junior high school students' scientific literacy tests on the theme of global warming with the results obtained, namely valid and reliable measuring instruments and can be used to measure students' scientific literacy abilities in learning on the theme of global warming [6]. Research to look at the scientific literacy profile of students in Indonesia has also been frequently carried out, Zulaiha found that the scientific literacy profile of junior high school students in Cirebon City was still low where 72.13% of students' literacy is still in the low category [7]. Research on the learning media aspect has also been frequently carried out, one of which is Ramdani A., who developed Android-based learning media to improve students' scientific literacy skills [8]. There are many other studies that involve all aspects of learning in order to improve students' scientific literacy skills. However, the efforts that have been carried out have not yet shown results in the development of students' scientific literacy abilities in Indonesia.

Based on research conducted by previous authors, the fact in the field is that most teachers who are facilitators of learning in schools still do not understand scientific literacy terminology [5]. The scientific literacy abilities of science teachers in this study showed good results, namely in the good category, but they did not understand the term scientific literacy itself. Apart from

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the importance of knowing scientific literacy and being able to apply it in the learning process, a teacher must also be able to prepare good learning assessments and evaluations so that the teacher can find out whether the learning or cognitive development process has actually occurred in students. However, in reality, based on researchers' interviews with several teachers in the city of Medan, teachers still often use assessments or evaluation tools presented in printed books or questions whose category is not high order thinking skills (HOTS) questions. This fact certainly provides an answer to why the level of scientific literacy of students in Indonesia has not increased. Razak et al in their research found that HOTS questions had a significant effect on students' scientific literacy skills and lesson study on ecology and environmental material [9]. Marzano et al stated that assessments are carried out to determine the cognitive changes that students have experienced and also to determine the student's process in achieving these cognitive changes [10]. Therefore, to be able to find out the level of students' scientific literacy and the process of students becoming scientifically literate requires appropriate measuring or assessment and evaluation tools that are able to measure students' levels of scientific literacy. Evaluation or tests are an integral part of classroom learning [11]. Evaluation and tests are components of learning that cannot be separated. Anderson says that a mismatch between learning objectives, assessment and learning itself can cause problems [12]. High quality learning will not be beneficial for students in carrying out their assessments if the learning is not in accordance with the assessment, likewise if the assessment is not in accordance with the learning objectives, the results of the assessment cannot reflect the achievement of the learning objectives.

Based on the study and analysis of the problems above, in order to solve existing problems, it is important to carry out research on the development of the book "Science Literacy Assessment for Middle School Students" based on Ethnoscience in Indonesia. The assessment book that will be developed follows the 2013 curriculum learning indicators and the 2018 PISA framework scientific literacy indicators and is "wrapped" in ethnoscience in Indonesia, so it is hoped that this book can become a reference assessment for science teachers in science learning in junior high schools and can train them. scientific literacy abilities of junior high school students in Indonesia.

Methodology

The method used in this research is research and development. In research and development methods, there are several types of models. The model used is a 4-D model development. The 4-D (Four D) development model is a learning device development model. This model was developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel [13]. The 4D development model consists of 4 main stages, namely: Define, Design, Develop and Disseminate. However, in this article what will be explained is that it focuses on the stage of developing the test items which will then be compiled into the form of a scientific literacy assessment book for junior high school students. Before the assessment or test structure becomes a book, the test measuring instrument is tested first and its quality is seen using a classical analysis test. The data were obtained by using the instrument Validation Experts, and Trial Multiple choice questions by measuring Classical Test Analysis.

Before this question was tested on students, its content validity was tested on 5 science education lecturers at Medan State University and 6 teachers at 3 different schools in the city of

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Medan. The sample in this study was selected using a purposive sampling method. 3 representative schools in Medan City with a total of 437 students took this scientific literacy test.

Results and Discussions

In this section, we will explain the results of the quality test of scientific literacy tests based on Indonesian ethnoscience in grades 7, 8 and 9 of junior high school. The quality of this test measuring instrument is seen from its construct validity, reliability, validity, difficulty index, and discrimination index.

Construct Validation

A good test measuring instrument is a valid test measuring instrument. A valid measuring instrument means a test measuring instrument that can measure what it is supposed to measure [14]. This construct validity was carried out by involving 5 science education lecturers at Medan State University, and 6 experienced science teachers at three different schools in Medan City. The validity of this construct was carried out using a validity sheet developed by Wilson et al [15]. The results of this construct validity were then analyzed using the Content Validity Ratio (CVR) formula developed by Lawse [16]. The analysis results from CVR can be seen in Figure 1.

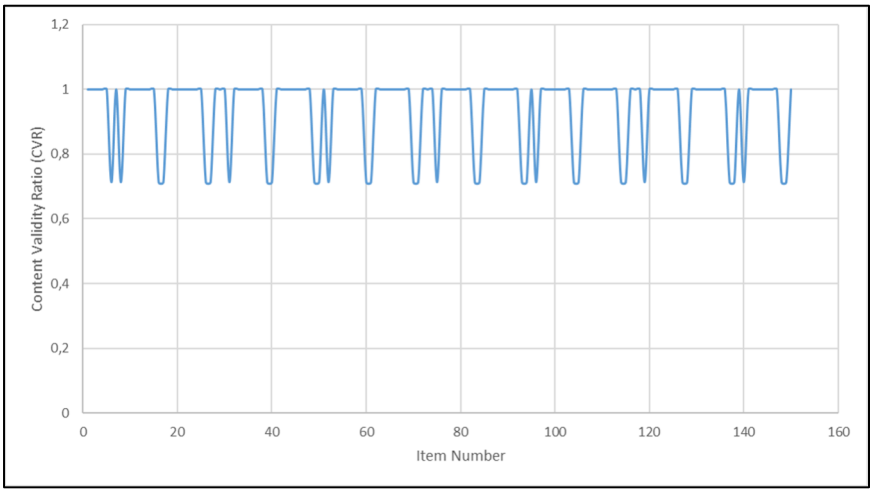

Figure 1. CVR score for each item of the scientific literacy test based on Indonesian ethnoscience for junior high school students

Based on the CVR test results for each test item above, then compared with the critical CVR value for the 11 panelists, namely 0.59. The test item is said to be valid if the CVR value is higher than the critical CVR value. Based on the results above, with an average CVR value of 0.94 and none below 0.59, it can be concluded that the 150 question items developed were proven to be valid in terms of constructivist.

Reliability

Test reliability needs to be measured to find out whether the questions can really measure what they are supposed to measure when used repeatedly. In this study, reliability was measured using the Kuder-Richardson formula (KR-20). The KR-20 value from the Indonesian

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ethnoscience-based scientific literacy test measuring tool is 0.85. According to Ding Lin and Beichner R., if the KR-20 value of a test measuring instrument is greater than 0.70 then the test measuring instrument is considered reliable for use in group tests. If the KR-20 value is greater than 0.80, then this test measuring tool is reliable for measuring individual student abilities [17]. Based on these categories, it can be concluded that this Indonesian ethnoscience-based scientific literacy test measuring tool is reliable for group and individual tests.

Discrimination Index

A good test must be able to have a good discrimination index. A test is said to have a good discrimination index if the test can differentiate between high and low group students based on their literacy ability test results. The better the discrimination index of a test measuring instrument, the better the test measuring instrument will differentiate between high and low ability groups. A test category that has a good discrimination index if the discrimination index value is equal to and greater than 0.3. The average discrimination index score for the Indonesian ethnoscience-based science literacy test is 0.5. The discrimination index value of the Indonesian ethnoscience-based scientific literacy test measuring tool can be seen in Figure 2.

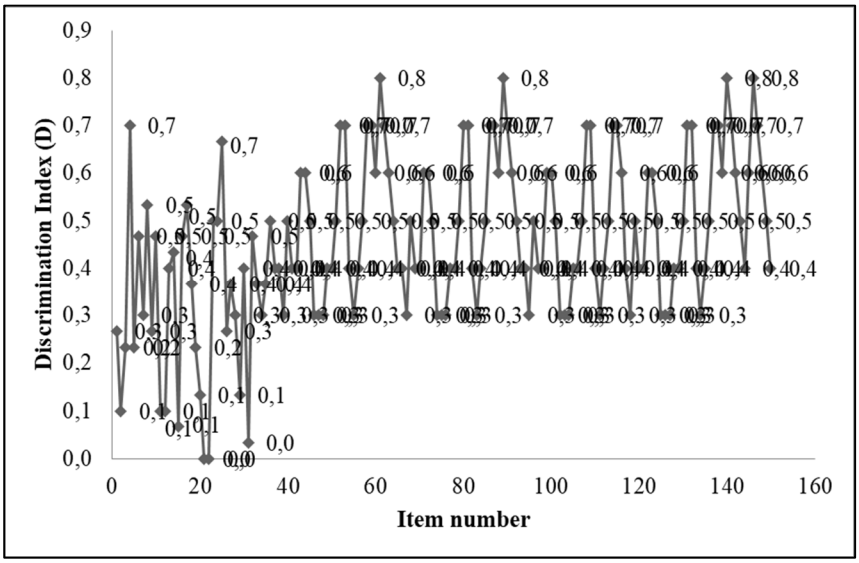

Figure 2. The discrimination index value of the Indonesian ethnoscience-based scientific literacy test

We can see, based on the graph above, there are several question items that show a value below 0.3. This will later be a consideration in determining whether the questions will remain in use, be revised or discarded.

Difficulty Index

A good test measuring instrument must also have a good difficulty index. A good question is a question that is neither too difficult nor too easy. A good difficulty index has a value between 0.3-0.9 [17]. The difficulty index value of the ethnoscience-based scientific literacy test measuring tool in Indonesia can be seen in Figure 3. The average value of the difficulty index for Indonesian ethnoscience-based scientific literacy test questions is 0.7. Based on the average obtained, it can be seen that this test measuring instrument has a difficulty index in the medium category.

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However, from Figure 3 we can see that there are still several test items that show scores above 0.9 and below 0.3, which indicates that the test items have a very easy and difficult difficulty index. Therefore, this will be a consideration for researchers in determining questions to be revised, replaced, or discarded.

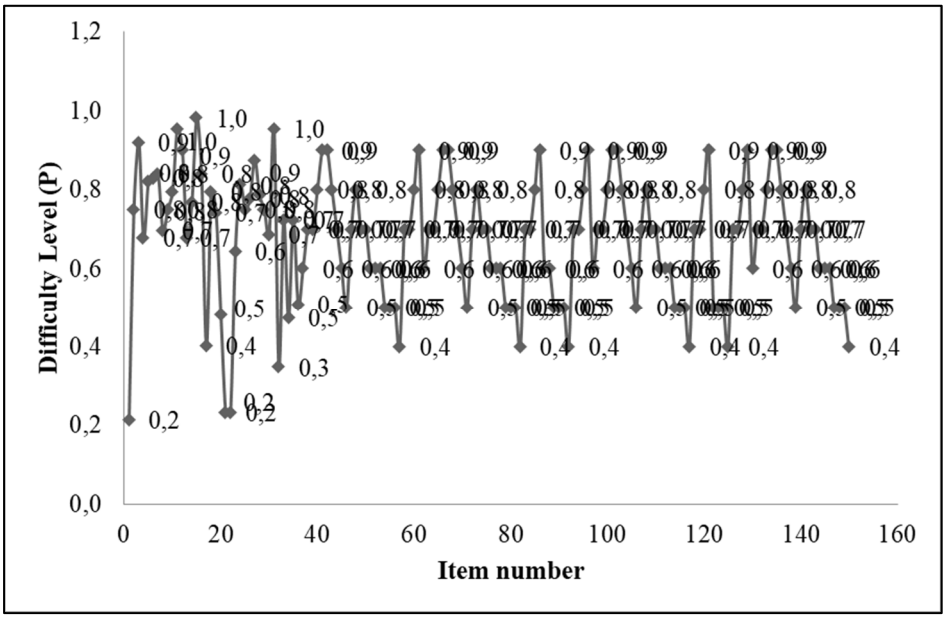

Figure 3. Difficulty Index Value of Ethnoscience-based Science Literacy Test Questions in Indonesia

Ferguson Delta

Ferguson delta is a formula used to obtain a value that shows whether a question has good overall discrimination ability. A test measuring instrument is said to have good overall high and low group discrimination capabilities if it has a Ferguson Delta value above 0.90 [17]. The Feguson Delta value from this test was obtained at 0.98. Therefore, it can be concluded that the Indonesian ethnoscience-based scientific literacy test measuring tool has good discrimination abilities.

Point biserial coefficient

The point biserial coefficient is the reliability value of test items obtained by looking at the correlation relationship between the score per item and the total test score. The biserial coefficient value of the Indonesian ethnoscience-based scientific literacy test as a whole can be seen in Figure 4. The test biserial point coefficient value is said to be good if the value is large or equal to 0.2 [17]. Based on the graph, it can be seen that there are several questions that have a value below 0.2 which then becomes a consideration for researchers to determine if the questions should be corrected, discarded or replaced.

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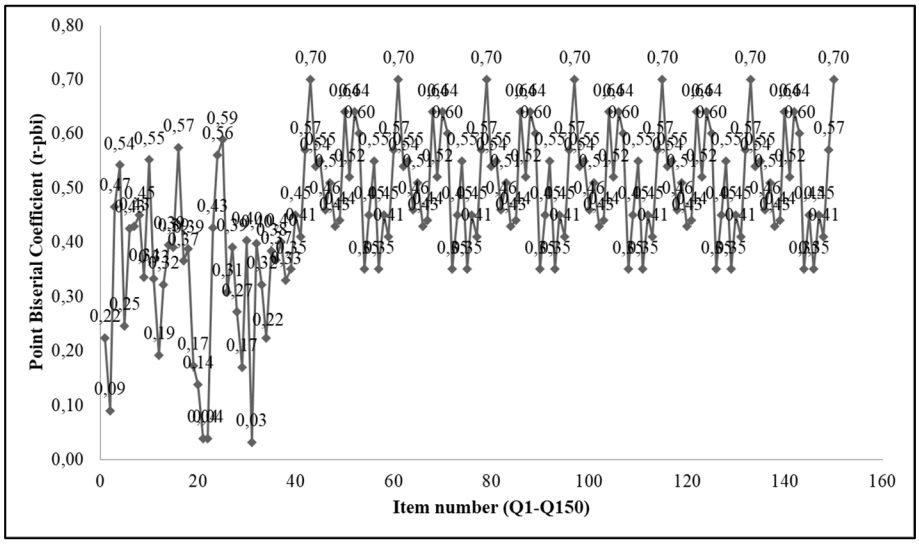

Figure 4. Point Biserial coefficient value of Indonesian ethnoscience-based scientific literacy test

All results of the quality test of scientific literacy tests based on Indonesian ethnoscience can be seen in Table 2.

Tabel 2. Recapitulation of all quality test results of scientific literacy tests

Quality Test Category	Value form Research	Desire Value
Reliability	0.85	≥0.70
Discrimination Index	Average of 0.5	≥0.30
Difficulty Index	Average of 0.70	0.30-0.90
Ferguson Delta	0.98	≥0.90
Point biserial coefficient	Average of 0.46	≥0.20

Based on the table above, all measurements of the quality of the test measuring instruments were taken into consideration in developing ethnoscience-based scientific literacy test questions in Indonesia for junior high school students so that a total of 140 test questions were obtained that were valid, reliable and had a good difficulty index and discrimination index.

Conclusion

The development of scientific literacy test for middle school students obtained 140 items tests were valid and reliable. Validity and reliability of the test indicate that the developed instrument can be used to measure the concept of science in 7th, 8th, 9th grade, and show consistent results. The test can discriminate well between high-performing students and low-performing students. Overall evaluation of the scientific literacy test showed positive results. Thus, it can be used to measure the level of students' scientific literacy in learning. It was also revealed that the test can be used by teachers as an evaluation tool for teachers on science learning.

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Developing a stem-based interactive e-module to improve tpack of prospective science teachers through lesson study

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Abstract. *This study aims to produce an interactive e-module based on STEM in enhancing the TPACK of prospective science teachers on work and energy learning materials and to determine the feasibility of an interactive e-module on basic science and laboratory activities courses. This research and development refer to the model developed by Thiagarajan, namely 4D. The development procedure includes the definition, design, and development stages through the implementation of lesson study. The subjects of the small group trial consist of 8 prospective science teachers and the subjects of the large group trial consist of 28 prospective science teachers. Data collection uses expert validation sheets and questionnaires. Data analysis techniques use quantitative description. Results show that the STEM-based interactive e-module to improve TPACK of prospective science teachers according to material experts, learning design experts, and media experts lies in the interval of feasible and very feasible categories and gets very positive responses from prospective science teachers. The results imply that the development of STEM-based interactive e-modules through the implementation of lesson study is an effective way to produce STEM-based interactive e-modules that provide well-designed learning activities so that prospective science teachers can apply and improve their TPACK by using every learning activity contained in the e-module such as implementing PhET interactive simulations and creating a project that produces a real product.*

Keywords: e-module, stem-based, tpack, lesson, study

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Introduction

Information and Communication Technology (ICT) in the current era of globalization has become a fundamental need for digital society in supporting the effectiveness and quality of education. Educational innovation is vital to be implemented by utilizing ICT development to improve the quality of learning in Indonesia. The intended innovation must be able to improve the 21st century skills including problem-solving skills, collaboration, and using ICT advances. In this case, teachers and lecturers as innovators and as the main component in the education system in Indonesia should be able to integrate technology into the teaching-learning process. Teacher in the 21st century is required not only to be able to deliver teaching materials interestingly and be skilled in using technology, but teachers must have the competence of harmony between technology, pedagogy, and content called Technological Pedagogical Content Knowledge, TPACK [1].

In facing the era of globalization and digitalization in the 21st century, the development of prospective science teachers through the implementation of lesson study is crucial to be carried out to improve the competence of mastering TPACK so that later the prospective science teachers able to learn innovation for the tech-savvy Z and Alpha generations. Lesson study is a form of collaborative and sustainable professional development of educators through learning study as a basis for professional development of teachers and lecturers to improve the quality of learning and teaching through professional sharing methods [2,3]. The implementation of lesson study in Institute of Education and Education Personnel (IEEP) can be used as reflection materials in the education practice of prospective science teachers on TPACK competencies to prepare prospective science teachers in implementing learning innovation and applying teaching and learning strategies in the 21st century that are effective and efficient through lesson study experiences in school setting [4].

Innovation in learning to improve mastery of 21st century TPACK competencies that can be applied by utilizing ICT is the development of innovative teaching materials by integrating Science, Technology, Engineering, and Mathematics (STEM) based learning. STEM learning is a learning process that uses science, technology, engineering, and mathematics approaches, as the focus of problem-solving in everyday life [5]. STEM learning is learning that integrates four disciplines where science requires mathematics as a tool in processing data, while technology and engineering are applications of science.

One of the innovative teaching materials that can be developed by introducing and teaching STEM to students is a STEM-based interactive e-module. E-module or electronic module is an innovation from the development of a printed module, which is supported by software and connected to a computer/gadget to access it. E-module is an independent learning device that is systematically designed, interesting, and fun, displayed in electronic form, and contains multimedia content in it such as audio, animation, and navigation to achieve the expected competencies [6,7]. E-modules are called interactive if there are images, audio, video, and animation, and are also equipped with tests/quizzes and assignments used as evaluation materials for educators [8]. The characteristic of an interactive e-module is to make students self-instructional because the teaching materials in the interactive e-module can teach the students independently [9]. The applications used in making the interactive e-module are Canva, Flip PDF Professional, and App Builder stored in a form link that can be accessed both online and offline by using a computer/gadget wherever and whenever the students learn independently [8].

The material topic of work and energy is closely related to everyday life and it is one of the material topics taught in the basic science and laboratory activities course which directs the

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students to observe natural phenomena in daily life and to conduct experiments in the laboratory. Through a STEM-based interactive e-module, prospective science teacher students are trained in making innovative teaching materials with their TPACK competencies by implementing lesson study stages namely plan, do, and see to produce a quality interactive e-module to improve the 21st-century skills. Research by Rokhmaniyah and Surandari found an increase in the quality of teachers' professional competence and learning materials through the implementation of lesson study [10]. Furthermore, Dinata and Hodiyanto's research showed that the implementation of learning through lesson study with the help of e-books was able to increase student activeness and problem-solving skills during the learning process [11]. Based on the background described, it is necessary to conduct research with the research purpose is to producing a STEM-based interactive e-module that is valid and practical so that it is expected to be useful as a reference source in the learning process that improves TPACK of prospective science teachers.

Methodology

The research method used was research and development (R&D) by adapting the Thiagarajan 4-D model. This research applies lesson study to produce a quality interactive e-module. This study is only adapting define, design, and develop phases which are a part of lesson study stages namely the plan stage. The product developed is a STEM-based interactive electronic module containing the topic of work and energy. This research involved expert judgment and student response as a user. The interactive e-module developed was tested by two learning design experts, two media experts, and one material expert. The experts are lecturers in the science education department. The user respondents were prospective science teachers who took basic science and laboratory activities courses in the 2022/2023 academic year. Data analysis in this research is quantitative descriptive which uses Table 1 as criteria levels for teaching materials feasibility based on responses obtained from questionnaires filled out by prospective science teachers and experts.

Table 1. Criteria Of Teaching Materials Feasibility

Feasibility Level	Interval
Very Feasible	$3{,}25 < \text{score} \leq 4{,}00$
Feasible	$2{,}50 < \text{score} \leq 3{,}25$
Less feasible	$1{,}75 < \text{score} \leq 2{,}50$
Not feasible	$1{,}00 < \text{score} \leq 1{,}75$

Results and Discussions

The development of a STEM-based interactive e-module was carried out through lesson study activities. At the planning stage, a team of lesson study collaborated to develop learning materials in the form of learning design implemented in the STEM-based interactive e-module, course learning outcomes used to create chapter design, and content of teaching materials that utilize ICT in the STEM-based interactive e-module. Of course, the use of ICT through media equipped with interesting imagery features, animations, learning videos, simulations, interactive quizzes, attractive project design, and interesting student assignments is needed so that creating a teaching and learning atmosphere that is interactive and fun, not seem monotonous, and easy to understand. Learning design is the result of the analysis of needs and problems faced in learning and adjusting to the curriculum.

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The defining stages

Three analyses were carried out, namely, curriculum needs and potential problems in the basic science and laboratory activities course: (a) curriculum analysis, researchers reviewed the lesson plan of the basic science and laboratory activities course, outlined each meeting and course learning outcomes as well as the specific topic of each meeting, the results of the analysis found that there was no teaching material to support lectures, the unavailability of lesson plan in which STEM-based learning was implemented and the implementation of lesson study in lectures, especially in STEM-based learning had never been implemented. (b) Analysis of student needs for the STEM-based interactive e-module was obtained from the responses of 32 prospective science teachers who took the basic science and laboratory activities course to a questionnaire with 4 question items and data obtained: 1) as many as 87.5% said they needed the STEM-based interactive e-module; 2) as many as 78.1% of prospective science teachers felt bored to use only textbooks and PowerPoint teaching materials in lectures; 3) as many as 93.7% of prospective science teachers are very interesting if lectures have interactive teaching materials that can be used both online and offline; 4) as many as 84.3% of prospective science teachers like to read interactive e-module because of the appearance of interesting e-module content containing images, videos, sounds, animations, simulations, interesting project design, interactive questions, and hyperlinks so that it can increase learning motivation. (c) Analysis of potential and problems, through SWOT analysis (Strengths, Weaknesses, Opportunities, Threats). The strengths of the science education department at Universitas Negeri Medan, namely support the smooth learning process in the classroom through the existence of science and computer laboratories, digital laboratories, and other learning media and learning environments that are enough to support students' understanding of science concepts. The weakness found by researchers is that lecturers and prospective science teachers still lack or rarely reflect on the learning that has taken place so far and have never implemented lesson study. The opportunities are that lecturers and students who are prospective science teachers may use the advantage of the facilities and infrastructure, as well as the competencies they need to develop teaching materials by utilizing technology. Meanwhile, the threat is that the mastery of the harmonious competencies of pedagogy, content and technology is still lacking in education practice or training which has an impact on the learning process being less than optimal.

The designing stages

The next stage carried out was design. The activities carried out at this stage included: (1) media selection about determining the right media to present science learning materials. This was adjusted to the material analysis and the facilities available in the learning environment, and (2) format selection was adjusted to the factors that have been described in the learning objectives. The format chosen was to design the appearance, content, and selection of learning activities and designs, (3) the initial design was the design of the content of an e-module intended to integrate science, technology, engineering, and mathematics in producing interactive and interesting learning including learning outcomes, learning objectives, material descriptions in concept map, interactive questions, STEM contents, project design content, animations, images, PhET simulations, and learning videos displayed in the e-module, material summaries, evaluation and answer keys, (4) compiled the interactive e-module systematics such as designing flowcharts, media navigation structures, and storyboard.

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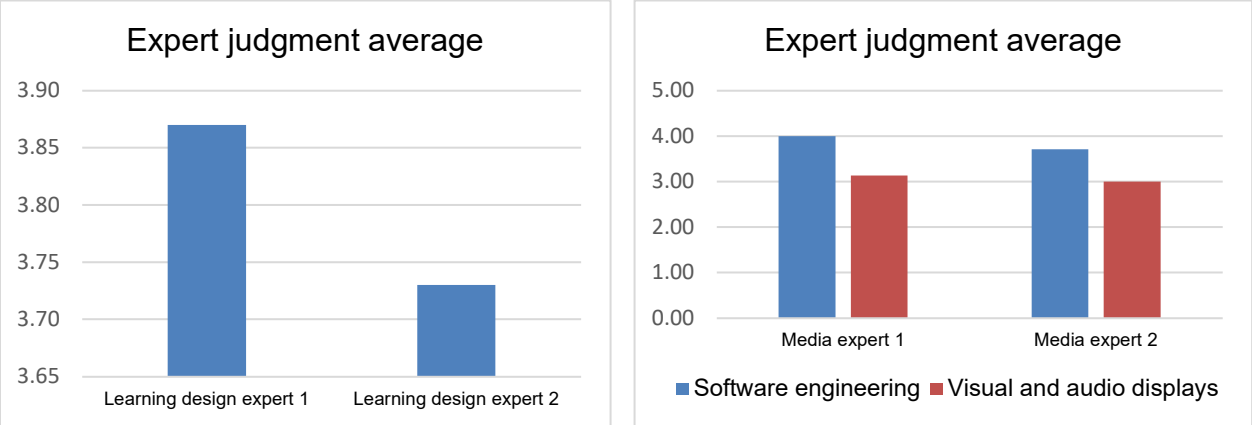
The developing stages

At this stage, the development of a STEM-based interactive e-module is carried out by the design that has been done. After the STEM-based interactive e-module has been developed, the next step is validation activities and trials of e-module products. The following described the results of validation by material experts, learning design experts, and media experts. The validity tests aim to determine the feasibility of the product that has been developed through the assessment of experts which includes material content validated by one lecturer, learning design, and media are respectively validated by two lecturers. The results of the material expert showed very feasible categories for each indicator, namely curriculum suitability, material accuracy, clarity of evaluation in e-module, accuracy of material presentation, conformity with Bahasa rules, and Science, Technology, Engineering, and Mathematics as shown in Table 2. The material expert provided suggestions on the STEM-based interactive e-module, which was the need for improvement in the writing errors of the terms used in the e-module content.

Table 2. Material Expert Judgment

Aspects	Score	Criteria
Curriculum suitability	4,00	Very feasible
Material accuracy	3,50	Very feasible
Clarity of evaluation in e-module	4,00	Very feasible
Accuracy of material presentation	3,75	Very feasible
Conformity with Bahasa rules	3,75	Very feasible
Science, Technology, Engineering, Mathematics	3,50	Very feasible

After the material expert validation, the e-module was continued for learning design and media validation. Both learning design experts assessed the interactive e-module by very feasible category shown in Figure 1(a). Learning design experts provided several suggestions on the STEM-based interactive e-module, including: (1) course learning outcomes need to be adapted to the STEM content in the e-module; (2) changing the word mathematics as a tool to mathematics as a calculating tool; (3) the use of words in the question provided must be logical and relevant. Figure 1(b) showed that both media experts evaluated the e-module as very feasible for the aspect of software engineering and feasible for the aspect of visual and audio displays.



(a) (b)

Figure 1. Experts' responses on questionnaires for (a) learning design expert and (b) media expert

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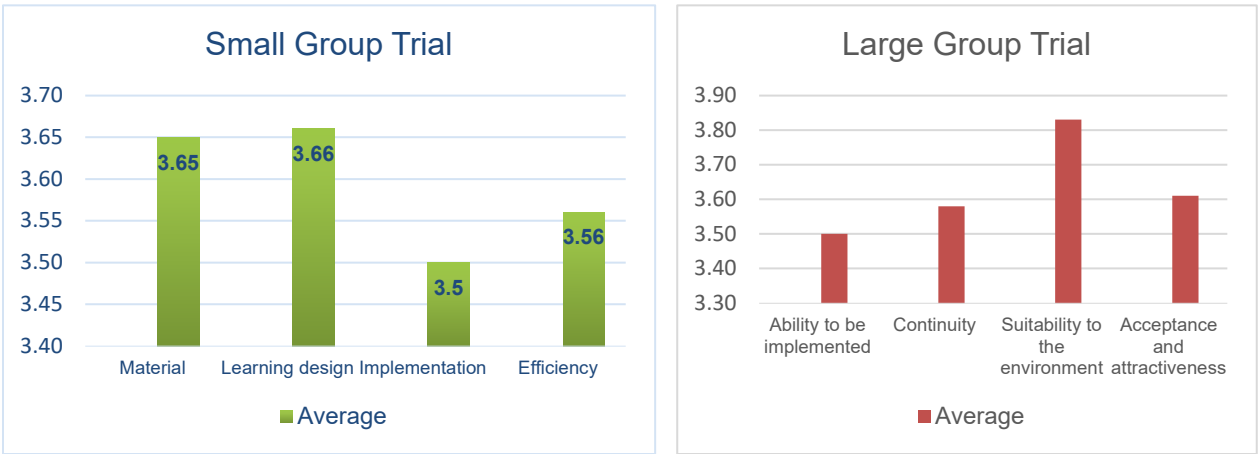
The researchers then tested the product in a two-group trial. The subjects of the small group trial consisted of 8 prospective science teachers and the large group trial consisted of 28 prospective science teachers. In the small group trial, 8 students were given a questionnaire comprising 14 questions with four assessed aspects: material, learning design, implementation, and efficiency. The student responses to the product for each aspect were very positive responses in the category of very feasible shown in Figure 2(a). Furthermore, according to the findings of the large group trial, 28 prospective science teachers were delivered a questionnaire consisting of 12 items with four indicators: ability to be implemented, continuity, suitability to the environment, and acceptance and attractiveness. All responses were very positive, and each indicator was in very feasible criteria as depicted in Figure 2(b). The product of the interactive e-module can be seen in Figure 3.



(a) (b)

Figure 2. Prospective science teachers' responses on questionnaires for (a) small group trials and (b) large group trials

Figure 3. STEM-based interactive e-module display

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Through STEM prospective science teachers are more interested, motivated, and actively involved in the learning process, increasing their understanding of the science content, and their participation in classroom discussions [12]. By using the STEM-based interactive e-module both online and offline, the students learn independently so that improving their learning comprehension and increasing their understanding of science content for those students who use it [13,14]. According to research by Davidi et al, STEM focuses on problem-solving and shows students how science, technology, engineering, and mathematics approaches are used in an integrated manner to develop products, processes, and systems that are useful to human life [15]. In addition, the product of the interactive e-module produced in this study can be accessed from the student's gadget or the student's computer. The interactive electronic module increases the student's interest in the learning process because it is accessible anytime, anywhere, supported by the right tools, and provides interactive learning activities.

Conclusion

A STEM-based interactive e-module to improve the TPACK competencies of prospective science teachers according to material experts, learning design experts, and media experts lies in the interval of feasible and very feasible categories and gets very positive responses from prospective science teachers. The development of the STEM-based interactive e-module through lesson study is an effective way to produce a STEM-based interactive e-module that provides learning activities designed so that prospective science teachers can use and improve their TPACK competencies by utilizing each learning activity contained in the e-module.

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Creating a model for developing creativity programs for Medan State University students

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Abstract. *The objective of this study is to establish a model for enhancing the Student Creativity Program (PKM) at Medan State University. This study falls under the category of developmental research. The output of this investigation is the formulation of the Medan State University PKM Development model, which aims to provide a high-quality Student Creativity Program derived from academic assignments utilizing the Case Method and Team-Based Project in accordance with KKNI (Indonesian National Qualifications Framework) guidelines, comprising six tasks. The research methodology employed is descriptive in nature. This research entails a comprehensive series of activities, encompassing stages such as research and data collection, planning, initial product development, preliminary field testing, primary product refinement, principal field testing, operational product enhancement, operational field testing, final product refinement, and dissemination and implementation. The findings of this research will be presented at the 2023 AISTSSE International seminar hosted by MEDAN STATE UNIVERSITY Medan. Additionally, the study will produce standard operating procedures (SOPs) and modules for the Medan State University PKM coaching model. The assessment of student learning outcomes, particularly the quality of proposals, is determined by the range of scores received by students. Notably, 83 out of 100 students achieved scores exceeding 600 points. According to the assessment criteria set by Belmawa Kemristekdikti, a score of 600 is considered excellent and qualifies for government funding. In terms of effectiveness, 80% of students who scored above 600 points, equating to 83 students, met the stipulated requirements*.

Keywords: development, creativity, coaching

Introduction

Regarding the framework for enhancing student engagement, encompassing reasoning, talents, interests, well-being, social support, and supplementary activities, the reasoning program pertains to student initiatives aimed at fostering a scientific mindset, stimulating creativity and innovation, enhancing research and academic paper writing skills, comprehending their chosen fields, and promoting collaborative teamwork within their universities and across institutions, both domestically and internationally. These endeavors may manifest as National Student Science Week, Student Writing Competitions, Student Creativity Development, National Student Achievement, and similar undertakings. The focus of this research lies in creating a model for

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advancing the Student Creativity Program within the realm of reasoning, particularly as expressed in the activities of the National Student Science Week.

Higher education graduates are expected to possess proficiency in academic knowledge, critical thinking, managerial capabilities, and effective communication. A deficiency in any of these four areas may compromise the quality of graduates. The synergy of these competencies is reflected in graduates' ability to promptly devise solutions to the challenges they encounter. Consequently, students' attitudes and actions will exhibit creativity, uniqueness, utility, and constructive outcomes. Students' creative thinking and problem-solving abilities can find expression through the PKM Student Creativity Program. PKM was designed to guide students in reaching a heightened level of creative and innovative thinking, grounded in a sound understanding of science and technology, and underpinned by a strong foundation of knowledge. To equip students with the skills, attitudes, responsibilities, teamwork, and autonomy required to become intellectual leaders and astute entrepreneurs, they are afforded the opportunity to cultivate these attributes through creative pursuits in their respective fields of study.

Due to the increasing expectations for the excellence of university graduates and the imperative for Medan State University students to be well-prepared for prestigious events like PIMNAS, there's an undeniable need for early readiness. This study is driven by the objective of creating an effective and top-notch coaching model for PKM (Student Creativity Program) tailored specifically for Medan State University students. Given this context, the research questions to be addressed are as follows: 1) What constitutes a model for enhancing the Medan State University student creativity program? 2) Is the resultant model both workable and pragmatic for implementation? 3) Does the resulting model prove to be effective?

Research Method

The term *"pembinaan*" can be traced back to the word *"bina*", which essentially means the same as "building." Coaching (*pembinaan)* is defined as a process or method focused on guiding and enhancing a group of individuals or learners to bring about change with the aim of achieving positive outcomes [1]. In essence, coaching can be thought of as a form of construction, involving the transformation of something to make it new and more valuable. Coaching also involves the notion of revitalization, adapting something to better meet the needs, ensuring it becomes successful and efficient in nurturing high-quality human resources.

Describes a coaching program as a structured procedure that serves as the foundation for determining the content and sequence of coaching events to be executed. This program encompasses specific goals, content, approaches, and coaching techniques. Coaching is an endeavor to ensure that individuals within an organization consistently adhere to established principles and carry out a series of activities as per predetermined plans [2]. The coaching function comprises three sub-functions: supervision (control), oversight (monitoring), and tracking (observation). Supervision typically focuses on the organizations responsible for program administration, oversight is directed at those carrying out the activities, and monitoring is focused on the implementation process of the program. The overarching purpose of the coaching function is to uphold and guarantee the consistent execution of the program as originally planned [3].

Coaching involves a systematic process as a business initiative and efficient activities aimed at achieving improved outcomes. It's an activity that sustains and enhances existing practices by regularly executing and evaluating these activities to make them more effective [4]. At Medan State University, coaching extends from the university level to encompass both lecturers and

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students, facilitated through the guidance of heads of departments. The syntax of the coaching model used is as follows:

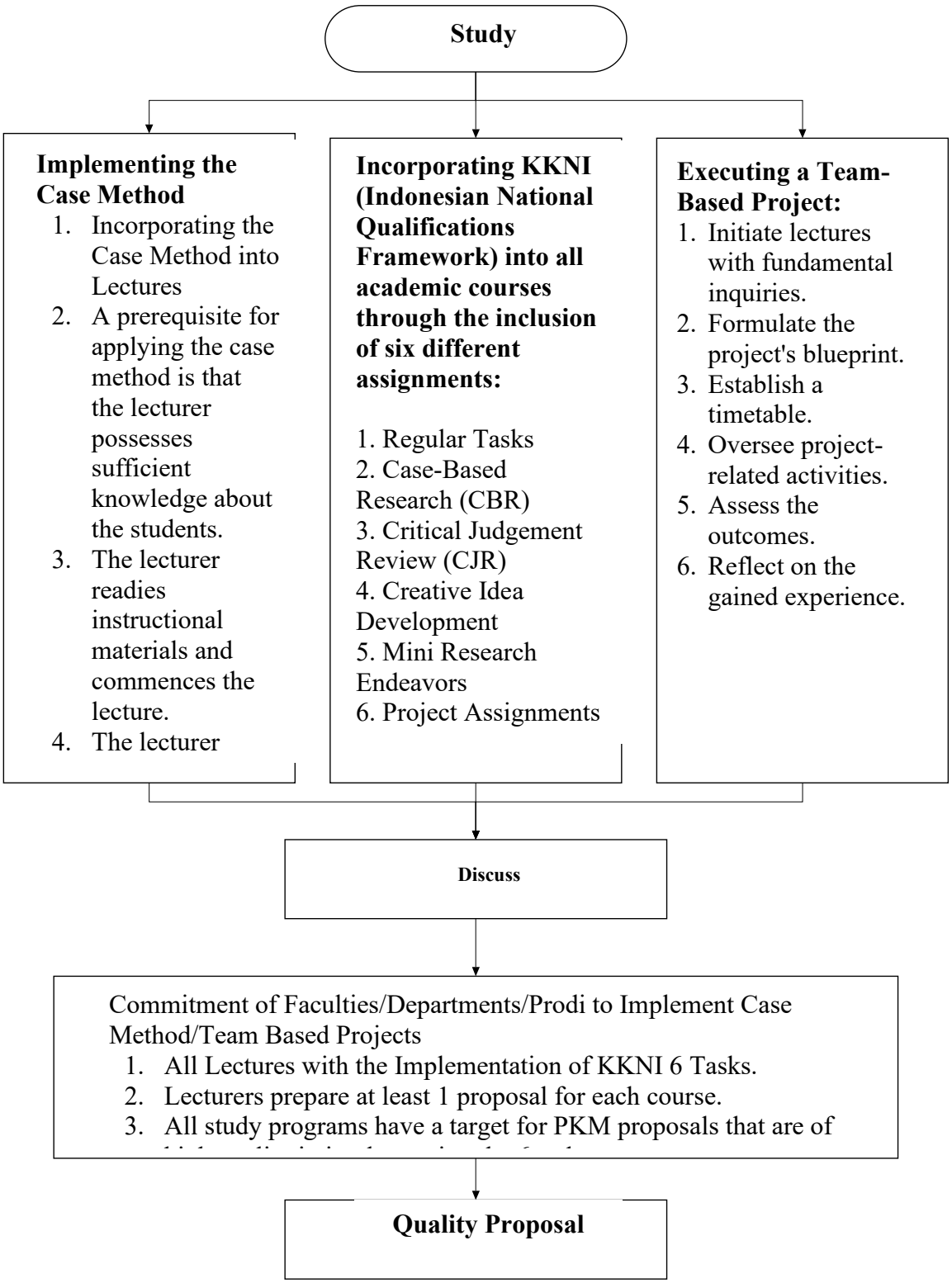

Figure 1 Syntax of the Medan State University PKM Development Model

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In the process of implementing the KKNI (Indonesian National Qualifications Framework) within lectures at Medan State University, it has devised the Cased Method and Team-Based Project-Based PKM coaching model. It also has applied the product development model outlined to ensure the quality and appropriateness of our educational products. Development research procedures primarily involve two key objectives: (a) developing products to fulfill their intended functions and (b) assessing the effectiveness of these products to validate their alignment with the objectives [5].

Consequently, development research entails a dual focus on both enhancing the product and validating its effectiveness. To create our learning model development plan, we have undertaken the following steps: (1) Initial development planning, encompassing the analysis of instructional needs, determination of instructional objectives, instructional analysis, and identification of initial abilities and student characteristics. (2) Development phase, involving the creation of benchmark tests, development of instructional strategies, selection and creation of instructional materials, and the planning of learning resources. (3) Evaluation and revision, encompassing both formative and summative assessments.

The findings from demonstrate that the utilization of case-based learning methods, specifically the case method, leads to an increase in the average scores of tax courses and boosts students' tax awareness. This shift fosters a generation of students with heightened tax consciousness within the Economic Education Study Program at FKIP Jambi. Evidently, this improvement is evident when considering that, in the initial cycle, 57.14% of students fell into the "good" category in terms of tax awareness, with only 42.86% reaching the "very good" category [6].

In line with these results, assert that the case method-based approach serves as a viable choice for instructors seeking to cultivate high-level thinking skills in students. By engaging students in both small and large group settings, this method encourages more active participation in the learning process. Students become adept at analyzing real-world phenomena or cases and connecting them to established theories [7].

On the other hand, found that, even during virtual lectures conducted via Zoom meetings, some students struggled to grasp the material and the discussed cases. This issue was attributed to students' reluctance to ask questions and a lack of interest in comprehending the material and explanations, whether from their peers or instructors. This underscores the effectiveness of the case method, as the level of participation and its impact on students' learning outcomes, particularly in enhancing critical thinking skills, remained inconclusive [8].

Furthermore, among the students taking change management classes, 36% of them reported a positive impact from the implementation of the case method. This approach aided in the development of problem-solving abilities, intellectual skills, and the fostering of independent learning. In light of the background and theoretical underpinnings outlined, the hypothesis of this research posits that the Medan State University PKM Development Model is not only suitable and practical for implementation but is also effective in achieving its intended goals.

Result and discussion

This study encompasses development research, often referred to as "research-based development," with the primary objective of enhancing the quality of education. Beyond the refinement and validation of educational outcomes, this development research is instrumental in the creation of the Medan State University PKM coaching model, designed to foster the creativity of Medan State University students. The qualitative research methodology is employed

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to evaluate program indicators, gauge student responses, and measure the changes in students' reasoning and creativity.

Educational research and development (R & D) is a process used to develop and validate educational production." This definition underscores the cyclic nature of research and development, where each step builds upon previous findings to generate a new program. Outline a sequence of stages that must be undertaken in this approach, encompassing "research and information collection, planning, development of a preliminary product, preliminary field testing, major product refinement, major field testing, operational product revision, operational field testing, final product refinement, and dissemination and implementation." Conceptually, the research and development process in this study comprises these 10 general phases [5].

The model's viability will be determined by the validation of the learning tools and instruments used. Practicality will be assessed through the application of syntax, social systems, and management principles, along with reactions to the model's implementation. Effectiveness will be evaluated based on learning outcomes and the quality of PKM proposals, the percentage of proposals meeting requirements, and the lecturer's ability to guide students through the learning process.

Prior to field deployment, all instruments undergo a validation process. Validation for the implementation plan of the Medan State University Case Method and Project-Based PKM Student Development Model within the framework of KKNI involves assessing the following aspects: (1) Competency and indicator formulation, which includes the clarity of core and basic competency formulation, the adequacy and completeness of indicator formulation, and the alignment of indicators with basic competencies. (2) Organization of learning materials, encompassing the suitability of teaching materials for basic competencies, the consistency and systematic arrangement of materials, compatibility with student characteristics, and adherence to time allocation. (3) Learning strategies/methods, evaluating the application of learning syntax, the provision of learning stages to attain competency, opportunities for students to gain concrete, meaningful experiences, active engagement in problem-solving activities, discussion, and reflection, all tailored to student characteristics. (4) Selection of learning sources and media, examining the suitability of these resources with learning materials, their alignment with student characteristics, and their compatibility with basic competencies. (5) Evaluation of learning outcomes, which involves assessing the appropriateness of evaluation types and formats with competencies, the alignment of question items with indicators, and the clarity of assessment procedures.

The expert evaluation of the learning implementation plan yielded the following results:

Table. 1 Validation by Experts of Learning Implementation Blueprints

No	Aspects	Validator			Average Score
		1	2	3	
1	Formation of Competencies and Indicators	4.00	3,66	4.00	3,88
2	Arranging Educational Resources	3,75	3,75	4,00	3,83
3	Learning Method/Strategy	3,85	3,71	3,71	3,75
4	Choosing Educational Materials and Instructional Media	3,83	3,66	3,66	3,71
5	Assessment of Educational Achievements	4.00	3,66	3,66	3,73
					3,78

Analyzing the data presented in the table above, we can observe that the average scores in various aspects are as follows: In the aspect of formulating competency indicators, the average score is 3.88. In the aspect of organizing learning materials, the average score is 3.83. In the

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aspect of strategy and learning methods, the average score is 3.75. In the aspect of selecting learning resources and learning media, the average score is 3.71. In the aspect of evaluating learning outcomes, the average score is 3.73.

Considering the overall validation aspect of the Student PKM Coaching Model learning implementation plan, the average score is 3.78. This score, when referred to the predetermined validation criteria, leads to the conclusion that the level of validation for the implementation plan of the PKM student coaching model falls within the "valid" category.

For the validation of the Student PKM Development module in the assessment aspect, which includes the module's appearance (cover, design, print quality, text size) and module completeness (foreword, table of contents, module information, usage instructions, competency standards, core competencies, basic competencies, competency indicators, learning objectives, learning methods, instructions, material descriptions, assessment techniques, formats, and bibliography), the results of the expert assessment are as follows:

Tabel. 2 Module Validation by Experts

No	Aspects	Validator			Average Score
		1	2	3	
1	Modul Display	3,60	3,80	3,60	3,67
2	Modul Comprehensiveness	3,81	3,72	3,64	3,72
	Total Average				3,70

Upon a detailed examination of the data in the table provided above, it becomes evident that the average score for the module's aesthetic quality is 3.67, and the average score for its comprehensiveness is 3.72. When considering the average score across all aspects of the module validation assessment, it amounts to 3.70. In line with the criteria established for determining the level of validation, it can be deduced that the validation status of the Medan State University Student PKM Program coaching module falls within the "valid" category.

The outcomes of the validation evaluation for the practicality of the Medan State University Student PKM development model are as follows:

Table 3 The outcomes of the validation evaluation for the practicality of the Medan State University Student PKM development model

No	Aspects	Validator			Average Score
		1	2	3	
Syntax					
1	The degree of implementation of all phases of the model	3.80	3,60	4.00	3,80
2	Inclusion of vital elements in the educational process.	4.00	3,67	3,67	3,78
3	Execution of a series of tasks and cooperative efforts during the educational experience.	4.00	4.00	3.00	3,67
		Total Syntax			3,75
Social System					
1	Engaging students actively in the educational proc	4.00	4.00	4.00	4.00
2	The extent to which interactive elements (discussions, questioning, and debates) are put into practice	4.00	3.00	4.00	3,67
3	The degree to which cooperative, respectful, and mutually supportive interactions among students are realized	4.00	4.00	4.00	4,00
		Total Social System			3,89
Principal Reactions					
1	The educator's degree of implementation supports a favorable learning environment.	4.00	4.00	4.00	4.00

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2	The extent to which instructors encourage students to inquire, express their perspectives, and respond.	3.00	4.00	4.00	3.67
3	The level of implementation by educators offers scaffolding, directs work, and instills motivation.	3.00	4.00	4.00	3.67
		Total Principal Reaction			3,78
	Total Amount				3,81

Analyzing the data presented in the table above, it's evident that the average score for the aspect of syntax is 3.75, for the social system aspect it is 3.89, and for the reaction principal aspect, it is 3.78. When considering the overall average value, it stands at 3.81. Upon referencing the predetermined criteria for determining the level of validation, it can be concluded that the practicality of the PKM Program coaching model for Medan State University students is in the "valid" category, as the average score is 3.81.

To gauge the effectiveness of the PKM student development model, it's imperative to examine data related to student learning outcomes (such as the quality of student proposals) and the lecturers' aptitude in managing the learning process and guiding students.

a. Student Learning Outcome Data (Quality of Student PKM Proposals)

Information concerning the Quality of PKM Proposals by Students is presented in the table provided as Table 4:

Table 4 Quality of Student PKM Proposals

No	Value Range	Total Group
1	550-575	10
2	576-600	7
3	601-625	5
4	626-650	8
5	651-675	10
6	676-700	60

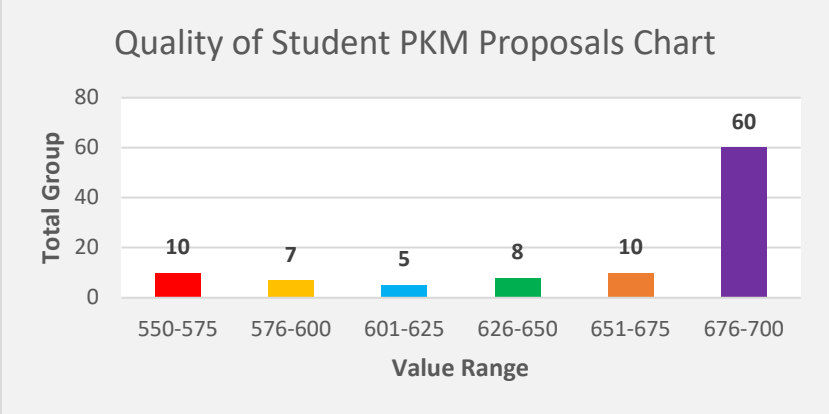

Figure 2 Score Quality PKM Diagram

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The assessment of student learning outcomes, as indicated by the quality of their proposals, is evident in the spectrum of scores achieved by students. A total of 83 out of 100 students secured scores exceeding 600. According to the evaluation criteria established by *Belmawa Kemristekdikti*, a score of 600 represents a level of quality considered very high and, consequently, qualifies for government funding. In terms of effectiveness, 80% of students who attained a score above 600 have met the stipulated requirements, which equates to 83 students.

a. The Competence of Academic Instructors in Providing Guidance to Students for the Formulation of PKM (Community Service Program) Proposals.

Information pertaining to the faculty members' proficiency in mentoring students on their PKM (Community Service Program) proposals is presented in Table 5:

Tabel 5 Instructor's competence in directing PKM (Community Service Program) proposals

No	Aspects	Observer 1/Score 1	Observer 2/Score 2	Average
1	**Creativity**			
	Entrepreneurial Concepts (evaluation of market opportunities with support from reliable data sources)	4	4	4
	Product Excellence (grounded in science and technology, distinguished by uniqueness and practicality)	4	3	3.5
	Business plan	4	3	3.5
	Average			3.66
2	**Program Potential**			
	Potential for Impelementation and Profitability	4	3	3.5
	Viability of Business Sustainability	4	4	4
	Planning of Activities and Personnel Assignments (comprehensive, transparent, fitting in terms of timing and personnel)	3	4	3.5
	Budget Preparation (thorough, detailed, rational, and transparent in allocation)	4	4	4
	Average			3.75
	Total Average			3.71

Examining the data presented in Table 5, it is evident that the overall mean score for the lecturers' proficiency in guiding Medan State University students in proposal creation stands at 3.71. Referring to the predefined criteria for assessing the lecturers' guiding ability, it can be inferred that the level of lecturers' guidance proficiency falls within the "good" category.

Taking into account the research findings related to learning outcomes and the lecturers' guidance capabilities, it can be deduced that the development of the PKM student coaching model has been effective. The lecturer's guidance proficiency for each guidance stage is visually represented in the following chart:

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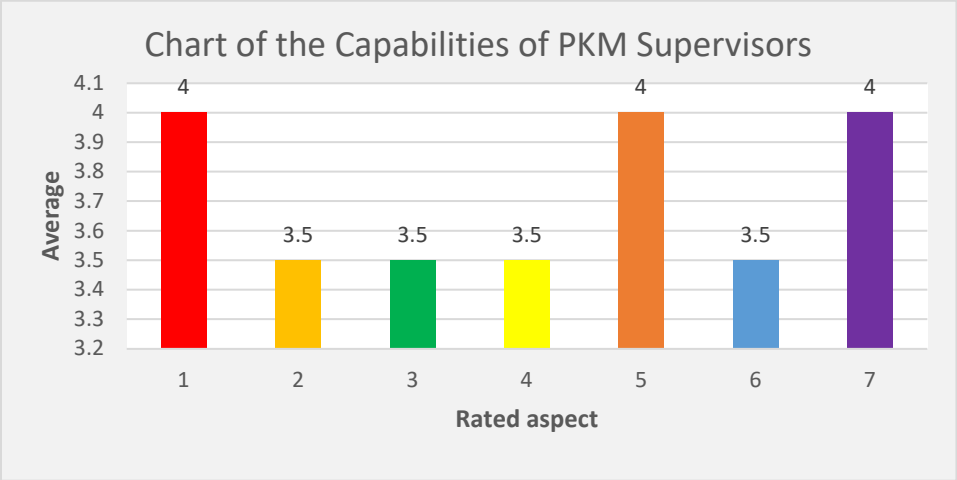

Figure 3 Chart of the Capabilities of PKM Supervisors

The insights derived from the depicted chart are as follows: 1) Conceptualizing Business Ideas (including market opportunity analysis and reliance on reliable data sources). 2) Achieving Product Excellence (rooted in science and technology, marked by uniqueness and practicality). 3) Formulating a Comprehensive Business Plan. 4) Assessing the Potential for Execution and Profit Generation. 5) Evaluating the Prospects for Business Sustainability. 6) Planning Activity Schedules and Personnel Allocation (ensuring completeness, clarity, and suitable timing and personnel assignment). 7) Crafting a Detailed Budget Plan (with completeness, transparency, reasonability, and clear allocation of resources).

Conclusion

The research findings yield the following conclusions:

1. The Medan State University Student PKM Development Model is both suitable and viable for implementation.
2. The Medan State University Student PKM Development Model is put into effective use.

Acknowledgment

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Development of the tpack-based project-based learning (pjbl) model for prospective elementary school teacher students' professional competence

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Abstract. *Several variables influenced educational quality throughout the industrial revolution, one of which was the presence of competent and professional teachers. However, the quality of prospective teacher students still needs to be strengthened in order for them to become professional teachers through increased personal abilities, understanding of science, and technology. The purpose of this study is to assess the validity, reaction, and professional competence of prospective elementary school teacher students toward the TPACK-based Project Based Learning model in Science Learning. Methodology of investigation The Plomp development model was used in the development of the TPACK-based Project Based Learning model, which consists of five stages of development procedures: analysis, design, development, implementation, and assessment. This development research produces material, learning design, layout, and language with an average percentage level of 96.25%, indicating that the TPACK-based Project Based Learning model along with learning tools is feasible to use. Student response data to the model's practicability obtained a positive value of 75, 8% and with appropriate criteria, while student responses to teacher professional competence obtained a positive value of 60% with moderate criteria. Based on expert evaluation, the proposed model was pronounced suitable for use by students, particularly in elementary school scientific learning in semester I. The student teachers' reaction to the generated model, which included lesson plans, textbooks, and LKM, was positive, with the majority of students stating that the developed TPACK-based Project Based Learning model was beneficial*.

Keywords: pjbl, tpack, professional, competence, elementary school.

Introduction

In the industrial revolution era, the quality of education was heavily influenced by a number of factors, one of which was the presence of knowledgeable and qualified instructors. In order to avoid misinterpretation during the process of teaching a concept, the instructor must be

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innovative and creative in presenting the material. The mastery of technology is essential for professors and professors to impart knowledge in a way that is clear and easily understood by students. Hasil survey PISA (Program for International Student Assessment) organized by OECD (Organization for Economic Cooperation and Development) reveals an increase in the average score of Indonesian students' ability to read, while scores in mathematics and science remain low (literacy with a score of 371, mathematics with a score of 379, and science with a score of 389) [1]. This is also consistent with the TIMSS (Trends in International Math and Science) survey, which indicates that only 5% of students in Indonesia are able to solve high-level problems without penalty [2].

Relevant to the PISA and TIMSS survey results, there must be an improvement in teacher quality in order to produce more competent elementary school students. Based on the findings derived from interviews conducted with prospective teacher students at PGMI IAIN Lhokseumawe, it was observed that the professional competencies of these individuals were not adequately cultivated. This deficiency was evident in their ability to prepare comprehensive lesson plans and develop teaching materials that effectively incorporate technology-based learning media. The findings of a preliminary study conducted on the TPACK competencies of prospective teacher students revealed that there was no significant improvement in their TPACK competencies in lesson plan preparation, as indicated by a hypothesis test score of only 6.2%. However, a positive impact was observed in their digital literacy competencies, with a value of 77.2% in terms of their ability to prepare lesson plans for elementary schools [3].

On the basis of the initial issue, it is clear that there is a need for an improvement in the quality of education in primary schools that emphasize children's experiences. In addition to technological expertise, a teacher's ability to select the most effective teaching methods and models can help students develop higher-level thinking skills. The paradigm of project-based learning, also known as the project-based learning (PjBL) model, is one of the pedagogical tenets of the curriculum, particularly of the independent curriculum. Project-based learning is a teaching approach in which students grasp questions or problems in the real world through a necessary inquiry process. In their study, Hossein et al, found that the presence of a teacher's mentoring toward a child during the implementation of the PjBL learning model makes it easier for a child to create a final product, acquire knowledge or experience, improve his or her skills or abilities, and also integrate values from multiple sources [4]. According to previous research, the implementation of the PjBL model by educators has been found to have a favorable influence on student development, particularly when accompanied by a high level of professional competence. However, it has been observed that the allocation of time in practice poses a challenge and may hinder the attainment of all intended learning outcomes [5].

For teachers and assistant teachers, implementing the PjBL model in the classroom is not an easy task; rather, it requires commitment and the ability to plan projects, especially in the sciences, so that they are in line with the current curriculum. From the results of a study conducted on teachers in classrooms with students, it was determined that providing teachers with knowledge of the PjBL concept improves their ability to manage classrooms, especially in terms of designing and implementing projects with minimal resources, as well as enhancing their literacy skills and helping them better understand the world. By combining creative teaching with PjBL, it is possible to overcome some of the challenges of a pandemic in order to achieve learning goals through motivation and social support, particularly in virtual science education [6,7].

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The advancement of technology in the twenty-first century has created a requirement for teachers to not only possess Pedagogical Content Knowledge (PCK), but also be able to teach using technology. This can be accomplished by integrating content and knowledge through the use of appropriate technology. Koehler explains that TPACK is a framework for integrating technology into the pedagogy and content of the learning process [8]. Sintawati and Indriani state that the 4.0 education model requires teachers to be able to integrate technology into the learning process, and that teachers' abilities to integrate technology into the learning process can be viewed through the tools they possess [9]. In a few studies, TPACK has been integrated into the learning process, with a focus on the teacher's ability to select appropriate materials and technologies for use in the classroom; more recently, the results of an analysis of the teacher's TPACK competencies have been found to be superior to those of students, particularly in terms of TK, TCK, and CCK. Further, Dinara Joldanova et al, stated that integrating TPACK into instruction can increase students' motivation and effectiveness in the classroom because technology makes it easier for students to access the materials they need for class, as well as having an effect on assessment [10].

To be able to integrate pedagogy, content, and technology into instruction appropriately, teachers and aspiring teachers must possess essential professional competencies. The results of a study examining the relationship between the PjBL learning model, TPACK, and professional competencies indicate that using the PjBL learning model can increase students' perceptions of their learning experience and motivate them to learn effectively and improve their research, leadership, and interpersonal skills, leading to significant differences in their efficacy and professional competencies. In line with the development of the PjBL-based TPACK instructional model that has been the subject of previous research, more emphasis is placed on the development of teacher competencies in technological content knowledge, or TPACK, in order to support 21st century learning [11,12,13]. Due to this, researchers wish to conduct research in order to develop a PjBL-based TPACK model that can influence the professional competencies of graduate students and faculty members. Eventually, it is hoped that the findings of this research will contribute to the knowledge of what aspects or skills must be enhanced by teachers in order to teach 21st century skills to students through a project-based learning model integrated with TPACK.

Methods

This research employs the Research and Development method (R&D research method used to produce certain products and test the efficacy of these products, through a process or steps to develop a new product or improve an existing one, and can be accounted for [14,15]. The development model utilized in this study is the Plomp model, which comprises the analyze, design, development, and implementation stages.The developed tools will generate a Model Book, Semester Learning Plan, learning model, and evaluation utilizing the learning model for project-based learning that is based on TPACK. This study was conducted at IAIN Lhokseumawe's Madrasah Ibtidaiyah (MI) Teacher Education Department (PGMI). Twenty first-semester student prospective instructors at Madrasah Ibtidaiyah (MI) IAIN Lhokseumawe, Aceh Province, served as the study's data source.

This study's methodology and research design followed the stages specified by the Plomp model at each stage, including the initial investigation stages (models and learning tools), the

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design stage (learning models and learning tools, realization), testing, evaluation, and revision phases.

Questionnaires and observational guidelines served as the data collection instruments for this study. This instrument was created by identifying PjBL learning model indicators based on TPACK. Indicators were formulated by examining operational definitions provided by a number of experts in relation to research variables. All validation sheets in this study are used to assess the validity of the PjBL learning model, learning aids, and other instruments required to evaluate the professional abilities of prospective teachers.

This study employs quantitative descriptive analysis for its data analysis. The descriptive quantitatively analyzed data is derived from product evaluations conducted by material experts, media experts, student response questionnaires, professional ability questionnaires for prospective instructors, and observation sheets.

Result And Discussion

Result

This study was conducted using the Research and Development (R&D) methodology. The researcher referred to the PLOMP development model, which consists of five stages: analysis, design, development, implementation, and evaluation. Several supporting devices, including the validity of the SLP, the validity of the Science Module, and the validity of the assessment instrument, will be utilized in the development of the TPACK-based Project-Based Learning model. The subsequent step involves validation by experts and conducting preliminary trials with small groups. Twenty prospective elementary education teacher candidates from the first semester participated in the experiment.

In this investigation, the initial product was a valid and applicable project-based learning model. Pertaining to the applicability of the TPACK-based PjBL model, which employs lecture tools based on the theoretical mastery and practical experience of experts and practitioners. The effectiveness of the TPACK-based PjBL model is determined by the lecturer's capacity to manage learning in the classroom (model implementation) and student responses to model components and lecture activities. Experts and practitioners are provided with TPACK-based PjBL Model books, lecture aids, and assessment sheets in order to collect data. In the subsequent phase, specialists and practitioners assign a value to each indicator's evaluation aspect. Implementation of learning model syntax, social systems, and reaction principles is evaluated on five scales: very low (score 1), low (score 2), moderate (score 3), high (score 4) and very high (score 5) respectively. The results of the model's validity are shown in Table 1.

Tabel 1. Validation Results from Experts

Numb.	Experts	Validation Results Validasi	Description
1	Linguist	5	Valid for Use
2	Models	4,5	Valid for use with some modification
3	Material	4,3	Valid for use with some modification

Table 1 reveals that the linguists' validation results yielded a score of 4, indicating that the project-based learning tool can be used without revision. Further validation was performed by model experts, who determined a value of 4.5, indicating that the model could be utilized with

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minor modifications to the resultant model book. In addition, the researchers validated the science content with two experts and received an average score of 4.3, indicating that the learning product was usable but required minor revisions on multiple devices, specifically the science textbook that would be used by the lecturer. Therefore, the average evaluation of the experts was calculated to be 96.25 percent.

In addition, once the model and tools have been validated by experts, the next stage is to revise and test the TPACK-based project-based learning model with students in the first semester of science. Students are provided with science textbooks and student worksheets (LKM) that are incorporated with the TPACK-based project-based learning model during the science learning process. The responses of students to the practicality of the model are displayed in table 2.

Tabel 2. TPACK-based Results of Student Responses to the Practicality of the Project-Based Learning Model

Item Question	Average Value	Criteria
1	80	Positive
2	70	Positive
3	80	Positive
4	70	Positive
5	70	Positive
6	70	Positive
7	70	Positive
8	80	Positive
9	70	Positive
10	80	Positive
11	85	Very Positive
12	85	Very Positive
Average	75,833	

The findings presented in Table 2 indicate that when 12 questions were administered to a sample of 20 first-semester students, about 75.83% of the participants responded positively towards the implementation of the TPACK-based project-based learning model, along with its accompanying tools. Additionally, the present study observed a notable enhancement in the professional competence of aspiring teacher candidates following their utilization of the model and tools. The outcomes of this improvement are presented in Table 3.

According to the data presented in Table 3, an assessment of the professional competence of prospective teacher students was conducted using 17 questions based on 5 indicators of professional competence. The results revealed that out of the total number of students assessed, only 9 students demonstrated high levels of professional competence, while 5 students fell within the medium category, and 6 students were classified as having low levels of professional competence. Consequently, the average score obtained was 0.60, indicating that 60% of the students exhibited satisfactory professional competence as prospective teachers in the field of basic education.

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Tabel 3. Results of Professional Competency Student Prospective Teachers

Preliminary test results	Final test results	N-GAIN	Categories
50	51	0,333333	High
39	47	1,142857	Low
46	46	0	High
45	46	0,125	High
47	52	2,5	Low
39	44	0,5	Moderate
46	46	0	High
50	52	1	Low
46	46	0	High
41	45	0,444444	Moderate
47	47	0	High
52	52	0	High
45	45	0	High
41	46	0,625	Moderate
42	47	0,714286	Low
52	52	0	High
42	46	0,5	Moderate
49	52	1,5	Low
41	46	0,625	Moderate
48	52	2	Low
Average Value		0,600496	

Discussion

The primary objective of this study is to examine the enhancement of professional competence among prospective teacher students in the field of basic education. This will be achieved through the utilization of the TPACK-based project-based learning model, which has been previously created by scholars in the field. The research findings indicate that the project-based learning paradigm, which incorporates Technological Pedagogical Content Knowledge (TPACK), has been deemed legitimate and viable for implementation, as confirmed by expert validation. The initial experiments involved the implementation of the model, along with supplementary tools, in the context of science education for PGMI students in their first semester. By analyzing student feedback on various components of the model, such as model syntax, integrated science textbooks, and Project Based Learning models based on TPACK and LKM, it was observed that 75% of students expressed positive reactions. Moreover, subsequent to the execution of the aforementioned model, an assessment is conducted to gauge the enhancement in the professional aptitude of aspiring teacher candidates. This assessment encompasses five key indicators, namely the proficiency in comprehending and grasping subject matter, organizing and structuring information, comprehending and applying conceptual frameworks, and cultivating a scientific mentality that bolsters the subjects being instructed. Acquiring proficiency in both core

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competencies and basic competencies within the fields of study. The study revealed that a significant proportion of students, over 60%, demonstrated a high level of proficiency in various areas, including the development of creative and inventive subject matter, the cultivation of professionalism through reflective action, and the effective utilization of information and communication technologies for personal growth and development.

In regards to the cultivation of professional competence among students, it has been observed that the majority of students exhibit little progress in fostering creativity and innovation in their subject matter, as well as in cultivating professionalism through reflective practices. In order to effectively incorporate pedagogy, content, and technology in the learning process, it is crucial for teachers and aspiring teachers to possess professional competence. The utilization of the Project-based Learning (PjBL) model has the potential to enhance students' sense of belonging to the learning environment, thereby fostering motivation and facilitating effective learning. Furthermore, the implementation of PjBL has been found to positively impact the development of research, management, and social skills among students. Notably, significant disparities in self-efficacy and achievement scores were observed between pre-service teachers who experienced PjBL and the control group who did not receive PjBL [16,17].

The implementation of the TPACK-based project-based learning model is anticipated to serve as the primary means of enhancing the professional competence of prospective teacher students. This approach aims to facilitate a comprehensive understanding of the subject matter, the development of relevant instructional resources that align with contemporary advancements, and the cultivation of self-improvement. It is not solely focused on content mastery, but also emphasizes the integration of technology in instructional design and the production of meaningful projects for elementary school students. Professional competence refers to the ability to effectively apply independent guidance and counseling techniques, which are developed and refined through practical experience utilizing the academic competencies acquired in a real-world setting. This competence is essential for a comprehensive understanding and mastery of the subject matter, and is anticipated to facilitate students' educational advancement [18,19].

The implementation of the project-based learning model has demonstrated its potential in enhancing the professional competencies of aspiring teacher candidates. This is evident through the observed improvements not only in their comprehension of scientific concepts, but also in their ability to effectively design and execute science projects assigned by instructors, as well as their adeptness in delivering well-structured presentations to their peers. The enhancement of teacher performance and the improvement of education quality can be facilitated through the cultivation of professional competence. It is imperative that efforts to optimize teacher work correspond with the overarching educational objectives [20,21].

Previous research has demonstrated that the integration of creative pedagogy with Project-based Learning (PjBL) has the potential to address various obstacles encountered during the pandemic, thereby facilitating the attainment of educational goals. This approach effectively fosters motivation and facilitates the development of social connections, particularly in the context of technology-mediated science education [6,7]. According to a study conducted by Maritasari et al, the utilization of the PjBL learning model, supported by mobile learning applications, was found to have a positive impact on teachers' pedagogical competence [22]. This was evidenced by an improvement in teachers' performance abilities. Additionally, students who received this treatment demonstrated higher levels of motivation compared to those who did not receive the intervention.

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Hence, based on the findings, it is evident that the developed model, specifically the TPACK-based project-based learning model, is viable and has garnered favorable feedback from student teacher candidates. Furthermore, the implementation of the TPACK-based project-based learning model demonstrates a positive, albeit not statistically significant, effect on enhancing the professional competence of aspiring teachers in the field of elementary education.

Conclusion

The TPACk-based Project Based Learning model, which was developed, has been found to be appropriate for implementation based on the evaluation of experts, with an average approval rating of 96.25%. Additionally, students have shown a positive response to the model, with a participation rate of 75.8%. The implementation of the TPACK-based project-based learning model has been found to significantly enhance the professional competencies of aspiring teachers in the field of basic education, resulting in a notable increase of 60%. Prospective educators can gain a comprehensive understanding of academic content, particularly in the field of science, by engaging in a student-centered project-based learning approach. This approach not only facilitates the assimilation of knowledge but also empowers students to conceptualize and execute elementary projects, generate reports, and deliver presentations. Furthermore, students have the opportunity to employ appropriate technology in order to successfully accomplish a specific project. This, undoubtedly, serves as a means to facilitate the integration of science education in elementary schools at a later stage.

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Using chatbot ai for learning basic physics and chemistry concept in elementary school teacher education

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Abstract. *Students majoring in elementary school teacher education at Medan State University are required to complete the basic concepts of physics and chemistry courses. However, based on initial observations of 120 respondents, understanding of the concept of material in this course is still low. One of the reasons is that it was found that not all students majored in science when they were in high school. So their initial knowledge regarding the material contained in the course is limited. There is a need for an automatic answering machine service for Physics and Chemistry theories and concepts that are most often raised by students to solve problems. This research aims to develop Chatbot interactive learning media based on Artificial Intelligence (AI) to help students solve existing problems. The development of AI-based learning media uses the Research and Development (R&D) method, where the process of developing AI-based learning media is still at the Validation stage from Media experts, material experts and Design Experts, where the assessment results from experts are obtained The assessment given by learning expert validators was 87.67% with an increase in tests 1 to 3 of 22.67%, media expert validators 86.8%, a 30% increase, and material expert validators 87.6% with an increase of 30.93. %, which results show that ChatBot media can be used for learning, which can make it easier for students and users to get the material and exposure provided by ChatBot media*.

Keywords: interactive, media, chatbot, artificial, intelligence

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Introduction

The rapid development of science and technology (IPTEK) has a significant impact on human life [1]. One area that is greatly influenced by technological advances is education. In the current era of Industrial Revolution 4.0 and digital transformation, automation is key in various fields, including in the educational context [2].

One of the innovations in the current development of science and technology is artificial intelligence or artificial intelligence (AI) [3]. AI is a branch of computer science that enables machines to perform human-like thinking. AI refers to intelligence implemented manually in machines (including computers) or used by humans to understand the intelligence of humans and other organisms [4,5,6].

The presence of AI brings several benefits and challenges to humans. The advantages include the ability to help humans solve complex problems more efficiently and effectively, especially in terms of time and data processing [7]. However, on the other hand, the existence of AI also poses threats regarding human work. Nevertheless, it cannot be denied that the presence of AI has a positive impact, especially in the educational context [8,9]. The year 2023 is marked by fierce competition between leading technology companies to develop AI that can make it easier for humans to search and process data or information [10].

Learning planning is the process of formulating learning objectives and selecting appropriate methods, strategies and techniques, including considerations related to teaching materials, delivery of materials, and use of learning tools and media [11]. Learning planning continues to play a role as a specification of learning conditions that enable the development of effective learning strategies and products, both on a large scale and in more detailed contexts [12,13,14,15]. Therefore, it is important to continue to develop quality learning plans to keep up with current developments [16].

In the context of current developments, learning planning remains a very important aspect of the learning process. This is related to the nature of learning as an interaction where lecturers and students interact and communicate in two directions [17,18].

Considering the importance of interaction in learning, careful learning planning is an indisputable need. Lecturers as the main actors in the educational process need to have good abilities in planning learning [19]. However, it needs to be acknowledged that currently not all lecturers or teaching staff have adequate competence or skills in preparing appropriate learning plans.

One AI that will be very popular in late 2022 and early 2023 is ChatGPT. AI ChatGPT, ChatGPT is an AI that can respond to various commands in the form of questions or statements in real-time [20]. Currently, ChatGPT is still based on very general knowledge with broad knowledge, there is no ChatGPT that focuses on understanding and knowledge, which means there is still a lack of knowledge in the search process in certain fields [3,21]. The learning planning process remains a very crucial element in educational development with the use of various technologies that are currently continuing to develop [22].

Chatbot or ChatGPT is a learning media source that is easily accessible via Android devices, personal computers and laptops and is simple for users to understand, which can be accessed via links known as E-Learning [7], [10]. E-learning is learning that is structured to use electronic or computer systems to support the learning process. E-Learning is also known as web-based learning, online learning distributed through computer instruction, or known as internet-based learning. This is a learning model that utilizes a variety of learning material storage media via websites, including text messages, graphics, audio and video [8], [9], [23], [24]. Therefore, researchers are interested in researching "Using AI Chatbots for Learning Basic Concepts of Physics and Chemistry in Primary School Teacher Education", among PGSD (Primary School Teacher Education) students at Medan State University. It is hoped that this can provide a solution so that students can easily understand the basic concepts of physics and chemistry.

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Methodology

Types Of Research

This research includes development research with the meaning of research and development (R&D). The media developed in this research is a Chatbot based on Artificial Intelligence (AI).

The steps for development research (R & D) are a) Research and Data Collection, b) Planning, c) Initial Product Development, d) Product Validation to Validation by Learning, Media and Material Experts, e) Product Refinement, f) Wider Field Trial, g) Product Refinement Result of Wider Field Test, h) Final Product Trial, i) Revision or Refinement of Final Product, j) Dissemination and Implementation. In this research, the steps were only up to the Expert Validation stage.

Validation

The questionnaire filled out by validation experts aims to obtain constructive reviews and recommendations regarding learning media. This expert will evaluate the media based on several criteria, appropriateness of content, understanding of language vocabulary, dialogical and interactive aspects, suitability of language, and use of terms or icons. With the help of validation experts, learning media development can identify potential improvements and enhancements needed to make the media ChatBot learning is more effective and in accordance with the needs and understanding of its target users.

Validate the Quality of Learning Media

Questionnaire A is filled out by a team of learning design experts who are intended to provide criticism or suggestions for learning media, with an assessment of the feasibility of the presentation, and an analysis of the effectiveness of the media.

Validate the Quality of Media Appropriateness

Questionnaire B is filled out by a team of media experts who are intended to provide criticism or suggestions for learning media, with an assessment of the appropriateness of using the media.

Validation of Material Suitability Quality

Questionnaire C is filled out by Media Experts with lecturers who teach basic concepts of Physics and Chemistry, consisting of four aspects, namely: 1) Appropriateness of Content, 2) Appropriateness of Presentation, 3) Readability, 4) Components of Scientific Skills.

Implementation Stage

The steps taken in the implementation stage of this research are feasibility testing of the product that has been prepared by validation experts, and then making improvements that have been given input from validation experts, this is done for the perfection of AI media in its use, before testing and use for the student. The eligibility criteria have been determined.

Table 1. Assessment Eligibility Criteria

Elegibility Level	Evaluation	Score
Not Feasible	1	< 65%
Not Worth It	2	65%-74%
Worthy	3	75%-84%
Very Worthy	4	85%-100%

Results and Discussion

The results and discussion of this research begin with determining the AI ChatBot product, where this development was carried out by observing students and lecturers in the field of study. Researchers conducted interviews with lecturers regarding the learning methods and digitalization media that have been used. The results of the discussions that have been carried

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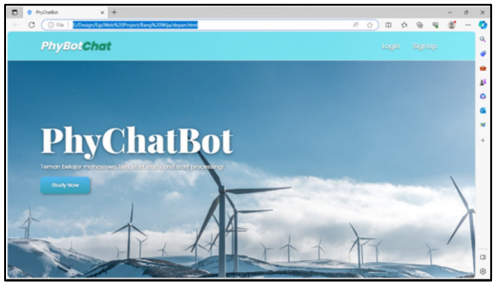
out require the development of digital media in learning, where researchers develop AI ChatBot media for the learning process.



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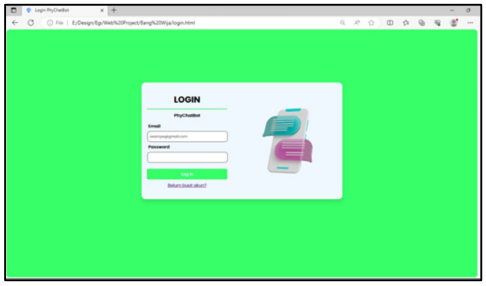

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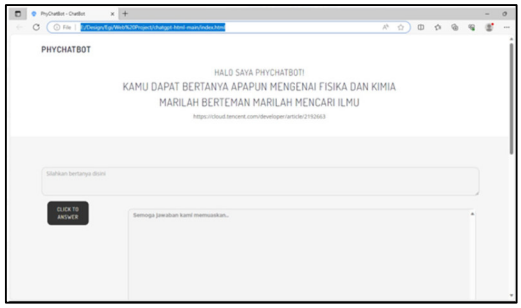

(c)

Figure 1. (a) Initial Screen, (b) Login, (c) Worksheet

The appearance of the AI ChatBot media that has been developed has been completed, and then the validation process is carried out, where the validation process is carried out by lecturers who are experts in design, media, and materials, this is done to perfect the learning media that has been developed, 3 experts are taken for each validation expert. each field with assessment criteria.

Table 2. AI ChatBot Media Assessment

No	Learning Expert	Media Expert	Material Expert
1	Chatbot Goals	Technical Quality Of Use	Conformity In Results
2	Accuracy In Use	Media Composition	Increasing The Quality Of Knowledge
3	Quality Of Use	Balance Of Use	Material Suitability
4	Accuracy	Cohesiveness	Effectiveness
5	Accuracy Of Content Results	Appearance	Feasibility Of Results

The validation process is carried out step by step until the AI ChatBot media is suitable for use, as for the results obtained from validation experts.

Table 3. Learning Expert Validators

Assessment Materials	Testing 1				Testing 2				Testing 3			
	Val 1	Val 2	Val 3	Average Rating	Val 1	Val 2	Val 3	Average Rating	Val 1	Val 2	Val 3	Average Rating
Purpose of ChatBots	65	60	65	63,33	75	75	80	76,67	80	85	85	83,33
Accuracy in Use	60	65	60	61,67	65	85	70	73,33	80	90	85	85,00

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Quality of Use	65	70	65	66,67	70	80	80	76,67	85	90	90	88,33
Accuracy	60	65	70	65,00	65	85	85	78,33	85	90	95	90,00
Accuracy of Content Results	65	75	65	68,33	75	85	80	80,00	90	95	90	91,67
Purpose of ChatBots	65	60	65	63,33	75	75	80	76,67	80	85	85	83,33

Assessment Materials	Average 1	Average 2	Average 3
Accuracy in Use	61,67	73,33	85,00
Quality of Use	66,67	76,67	88,33
Accuracy	65,00	78,33	90,00
Accuracy of Content Results	68,33	80,00	91,67
Purpose of ChatBots	63,33	76,67	83,33

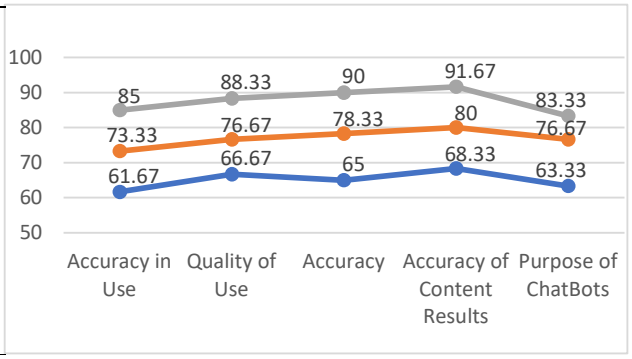

Figure 2. Average Results of 3 Learning Expert Validators with 3 Tests

The results obtained from the learning expert validator with 3 tests obtained a quite significant increase in value where the average value from Purpose of ChatBots 1 was 65% with the average increase in the second test being 77% where an average increase of 12% was obtained, from This increase requires improvements to produce better ChatBot media where the third validation test was carried out with an average score of 87.67% where the increase was 10.67%, from the 3 validation tests an increase in improvements to the ChatBot media was obtained. Learning Assessment was 22.67%. Obtaining the final learning expert validator score means that ChatBot media is very suitable for use in the learning process.

Table 4. Media Expert Validators

Assessment Materials	Testing 1				Testing 2				Testing 3			
	Val 1	Val 2	Val 3	Average Rating	Val 1	Val 2	Val 3	Average Rating	Val 1	Val 2	Val 3	Average Rating
Use of Chatbots	58	54	60	57,33	68	80	86	78,00	86	86	86	86,00
ChatBot Media Composition	56	58	56	56,67	68	82	78	76,00	80	86	86	84,00
ChatBot Balance	50	60	60	56,67	80	80	78	79,33	90	86	88	88,00
ChatBot Integration	56	54	58	56,00	82	84	80	82,00	86	90	86	87,33
ChatBot View	60	56	56	57,3333	82	80	80	80,67	90	86	90	88,67
Use of Chatbots	58	54	60	57,33	68	80	86	78,00	86	86	86	86,00

Assessment Materials	Average 1	Average 2	Average 3
Use of Chatbots	57,33	78,00	86,00
ChatBot Media Composition	56,67	76,00	84,00
ChatBot Balance	56,67	79,33	88,00
ChatBot Integration	56,00	82,00	87,33
ChatBot View	57,3333	80,67	88,67
Use of Chatbots	57,33	78,00	86,00

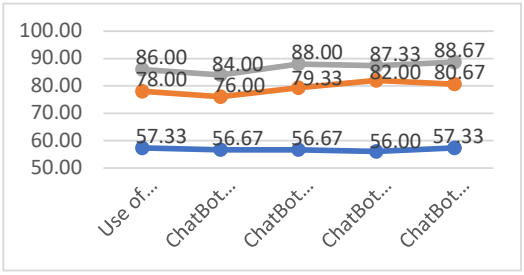

Figure 3. Average Results of 3 Media Expert Validators with 3 Tests

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The media expert validator score obtained with test 1 was 56.8%, test 2 was 79.2%, and test 3 was 86.8%, where the assessment from 3 media expert validator tests was 30%, from the average assessment of the 3rd test. A score of 86.8% was obtained, which states that it is very suitable for use in presenting ChatBot media.

The score obtained by the material expert validator with test 1 was 56.67%, test 2 was 81.07%, and test 3 was 87.6%, where the assessment from 3 material expert validator tests was 30.93%, from the average test assessment. The 3 rd score was obtained at 7.6%, which states that it is very suitable for use in delivering material on a ChatBot.

Table 5. Material Expert Validators

Assessment Materials	Testing 1				Testing 2				Testing 3			
	Val 1	Val 2	Val 3	Average Rating	Val 1	Val 2	Val 3	Average Rating	Val 1	Val 2	Val 3	Average Rating
Quality of Scientific Knowledge	54	60	58	57,33	82	78	86	82,00	86	90	86	87,33
Suitability of Material	58	58	56	57,33	80	80	78	79,33	86	86	90	87,33
Effectiveness of Use	60	56	50	55,33	84	80	80	81,33	90	90	86	88,67
Feasibility of Results	54	56	60	56,67	80	86	82	82,67	86	86	86	86,00
Accuracy of Presentation	56	60	54	56,67	82	78	80	80,00	86	90	90	88,67
Quality of Scientific Knowledge	54	60	58	57,33	82	78	86	82,00	86	90	86	87,33

Assessment Materials	Average 1	Average 2	Average 3
Use of Chatbots	57,33	78,00	86,00
ChatBot Media Composition	56,67	76,00	84,00
ChatBot Balance	56,67	79,33	88,00
ChatBot Integration	56,00	82,00	87,33
ChatBot View	57,3333	80,67	88,67
Use of Chatbots	57,33	78,00	86,00

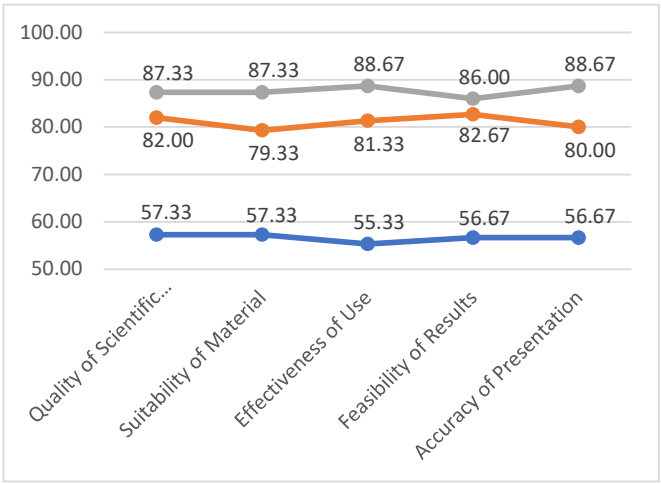

Figure 4. Average Results of 3 Material Expert Validators with 3 Tests

Conclusion

The assessment given by learning expert validators was 87.67% with an increase in tests 1 to 3 of 22.67%, media expert validators 86.8%, a 30% increase, and material expert validators 87.6% with an increase of 30.93. %, which results show that ChatBot media can be used for learning, which can make it easier for students and users to get the material and exposure provided by ChatBot media.

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Ethnoscience study of sinyar- nyar fish and sale fish typical batak angkola culinary in south tapanuli regency

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Abstract. *Ethnoscience is an activity of transforming the original science of society and scientific science, which is more easily observed through educational processes about everyday life developed by culture, both processes, ways, and methods. This study aims to describe and reconstruct scientific knowledge on the various kinds of special foods from South Tapanuli, both from the type of food and also from the food processing. The original knowledge contained within the community regarding these special foods needs to be traced, explored, studied, and then transformed into scientific knowledge that can be accounted for. The type of research used in this research is descriptive qualitative research with in-depth interview methods and direct observation of the Angkola Batak people in South Tapanuli Regency. The research showed the process of burning this Sinyar-nyar grilled fish uses firewood. In the process of burning fish, the energy used and the change in energy for burning fish is chemical energy, which comes from the bonding of compounds in the fuel (firewood), which is used to change to produce heat energy. The process of making sale fish starts with weeding, then the entrails of the fish are removed, split but not cut in half, then smoking continues. Under the smoking area, wood has been prepared while maintaining the flame so that the smoked fish is perfectly dry.*

Keywords: Ethnoscience, Batak angkola, sinyar-nyar, sale fish

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Introduction

The era of globalization, especially the globalization of the cultural sector, provides opportunities, especially for the Indonesian state which has a variety of ethnic groups and diverse cultures, such as traditional clothing, traditional clothing, traditional houses, regional dances and regional cuisine. Regional culture is reflected in various aspects of people's lives in all regions in Indonesia. Each region has distinct cultural characteristics. In the national culture there is a unifying element of the Indonesian nation which is already aware of and experiencing national distribution. In it there are elements of national culture and elements of foreign culture, as well as elements of new creations or national inventions.

The rapid flow of globalization in the 21st century has caused a shift in cultural values and local wisdom. The importance of integrating culture, potential and local wisdom is strengthened by the phenomenon of diminishing community interest, in this case students, in optimizing the potential that exists in their area. The free flow of information and technology into Indonesia will erode the nation's culture if there are no efforts to prevent it. The nation's culture from the aspect of science is still not explored and socialized, even though much of the original science of the community is in the form of local traditions and wisdom that have developed in society which have been passed down from generation to generation.

Ethnoscience is an activity of transforming between the original science of society and scientific science, which is more easily observed through educational processes about everyday life developed by culture, both processes, ways and methods. In the science learning process, ethnoscience is a strategy for creating a learning environment by integrating culture. Each region must have a local culture that can be utilized optimally as teaching materials for integrated science learning. If the local culture is used in accordance with relevant topics, it will provide various alternative activities to provide insight and knowledge for teachers and students.

South Tapanuli is a district in North Sumatra Province. The capital of South Tapanuli Regency is Sipirok. The original inhabitants of South Tapanuli are the Angkola Batak tribe, who are still closely related to the Toba Batak tribe. Apart from the Angkola Batak tribe, there are also other tribes, including the Toba Batak and Mandailing. In South Tapanuli Regency, there are many special foods that are a manifestation of the wisdom of the local community in managing and preserving regional food, such as hollat, lappet, arsik, and various other kinds of snacks.

This study aims to describe and reconstruct scientific knowledge on the various kinds of special foods from South Tapanuli, both from the type of food and also from the food processing. The original knowledge contained within the community regarding these special foods needs to be traced, explored, studied and then transformed into scientific knowledge that can be accounted for. The studies obtained will later be integrated into learning which is a form of effort to introduce students to typical foods and their processing and then be linked to scientific material and knowledge.

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Learning is carried out by associating local wisdom values around students with the aim that they know the local wisdom values around them and are expected to be able to maintain and preserve these local wisdom values so that they remain and are not displaced by outside culture and remain grounded in local cultural wisdom values. in the surrounding area as a character reinforcement so as not to lose identity. Therefore, learning science based on local wisdom is one way that can be done so that the nation's culture remains sustainable in the midst of globalization.

Ethnoscience in Science Learning

Ethnoscience comes from the word ethos from Greek which means nation and the word scientia from Latin which means knowledge. The term Ethnoscience or ethnoscience in general is the knowledge possessed by a nation or tribe. Ethnoscience is defined by Sudarmin as a set of knowledge possessed by a particular society/tribe/nation which is obtained using certain methods which are the traditions of a particular society/tribe/nation and empirically, the truth of which can be tested and accounted for [1]. Vlaardingerbroek states that Ethnoscience is the study of knowledge in a cultural context as cultural adaptation to the place where a person lives and practicing it in everyday life [2]. The scope of ethnoscience covers the fields of science, agriculture, ecology, medicine, even including flora and fauna [3].

Sudarmin states that there are three areas of ethnoscience research, namely 1) ethnoscience which emphasizes the culture of the social situation faced [1]. This research study shows symptoms about material that is considered important for society and how to organize these symptoms with the knowledge they have. 2) ethnoscience which emphasizes research in revealing the culture that exists in society in the form of prohibited and permitted values and norms as well as technological development. 3) ethnoscience which emphasizes culture as an event that can bring people together and influence daily behavior. The third research study is the study most often used as research study material in the scientific community.

Indonesia has a variety of cultures and local wisdom from various tribes and ethnicities. In general, local wisdom can be interpreted as a form of wisdom that is based on good values believed by local people. This local culture originates from ancient ancestors and is still maintained today. So that local culture does not become extinct, preservation must continue to survive as time goes [4]. Noble values need to be instilled and socialized, one of which is through the learning process at school.

According to Wikantiyoso & Tutuko and Fajarini, local wisdom usually describes a phenomenon that is characteristic of a particular community or region [5,6]. The local wisdom approach can be utilized by educators in the learning process. Ethnoscience as a study of the original knowledge framework or system of community culture and all phenomena related to the universe that grow in the lives of local communities. Ethnoscience integrated learning is a form of effort to introduce students to realities that have been created and developed in people's lives, then connected with scientific material and knowledge. Ethnoscience is also a learning that has

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the ability to plan students' learning experiences and incorporate parts of original science into learning at school.

According to Puspasari, ethnoscience-based learning is offered in the implementation of learning because it is in accordance with the learning implementation process in accordance with the 2013 curriculum which includes: observing, asking, collecting information, trying, and communicating [7]. The application of ethnoscience learning is not only in accordance with current developments and the rules of the educational curriculum currently adopted by the Indonesian people, but also aims to instill an attitude of love for their culture and nation, increasing students' knowledge and understanding of the culture and potential of their region.

Culinary of the Angkola Batak Tribe in South Tapanuli Regency

The Angkola Batak tribe is one of the Batak ethnic groups who inhabit the Padang Sidempuan, Sipirok and almost all of South Tapanuli areas. The Angkola Batak clan is related to other clans in the Tona Batak and Mandailing Batak areas. The ancestors of the Mandailing-Angkola tribe are said to belong to the Proto Malay (Old Malay) group which has similar physical characteristics to the Toba, Simalungun ethnic groups. Pakpak, Dairi and Karo.

So far, many people consider the native population of South Tapanuli (North Sumatra) to be all Mandailing and partly Toba ethnic. However, this assumption is very wrong. South Tapanuli before the regional expansion became South Tapanuli (capital of Padang sidimpuan, then Sipirok). Mandailing Natal (capital city Panyabungan). Since time immemorial it has been inhabited by indigenous people consisting of the Angkola and Mandailing ethnic groups. The Angkola Batak ethnic majority inhabits South Tapanuli today, characterized by the dominance of the Harahap and Siregar clans. The majority of Mandailing ethnic people live in the current Mandailing Natal area, with the dominance of the Nasution and Lubis clans. In the history of South Tapanuli, it is explained that Angkola has two important meanings. Angkola can be interpreted as a region, territory or region. Another meaning is that Angkola is an ethnic group that stands alone and is native to North Sumatra.

Research Method

The type of research used in this research is descriptive qualitative research. The data sources used in this study are primary data and secondary data using interview methods, direct observation of the Angkola Batak people. Data collection techniques are observation, semi-structural interviews. The data referred to in this study are comprehensive data regarding the unique culinary varieties found in the Angkola Batak tribe in South Tapanuli Regency. Data collection was carried out by using observation sheets, identifying the types of plants used in these various culinary types, the data collected included class, family, scientific name, local name, part of the plant used, habitus, method of processing, benefits, habitus.

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Individuals who will become informants in this study are the local people of the Angkola Batak tribe in South Tapanuli Regency. Direct observations were made in the field. The main instrument in data collection is based on community knowledge as much as is obtained, with verification, reconstruction, formulation and conceptualization into scientific knowledge. After verifying the primary and secondary data, then correlating scientific studies in the processing of various typical foods of the Angkola Batak Tribe with the aim of instilling and cultivating local wisdom values. The data from the interviews were grouped based on the composition of the food ingredients used, the parts used, processing methods and techniques.

Results and Discussion

Sinyar-nyar grilled fish

Sinyarnyar grilled fish is a type of typical food from the land of Sipirok, Sipirok District, South Tapanuli Regency, North Sumatra. Initially, Sinyar-nyar grilled fish came from the Simalungun area, then modifications were made to the spices. This food is a special menu in the Sipirok area. The fish used in making this sinyar-nyar fish is goldfish obtained from Lake Siais, South Tapanuli, where the fresh goldfish are first cleaned and grilled until cooked using firewood. Then the crushed chilies and andaliman will be doused with hot water. The additional ingredients in making grilled fish sinyar-nyar are Andaliman (sinyar-nyar), shallots, shrimp oranges (oranges grown in the South Tapanuli area) and additional vegetables, namely sweet potato leaves and kates leaves. Andaliman is the characteristic taste of this grilled nyar-nyar fish.

Andaliman is the characteristic taste of this grilled sinyar-nyar fish. The spice, which has the Latin name Zanthoxylum acanthopodium, is a type of flower in the citrus family. The plant whose skin is used is also found in many dishes in East and South Asia and is often referred to as Szechuan pepper. In North Sumatra it is known as "Batak Pepper". Andaliman is a clump of oranges containing natural vitamins C and E which function to maintain the body's immune system and also contains essential oil compounds and alkaloids which function as anti-oxidants and anti-microbials.

The grilled fish used is goldfish from Lake Siais, South Tapanuli, then before being grilled it is first placed in a temporary pond. Lake Siasis is the second largest lake in North Sumatra after Lake Toba. This lake is about 100 kilometers from Sipirok, the capital of South Tapanuli Regency. In this lake, there is a high diversity of fish species, and many local people use it to keep local fish such as Jurung fish, goldfish, kan lappam, baung fish.

Figure 1. Sinyar-nyar Grilled Fish

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The burning process for Sinyar-nyar grilled fish uses firewood. In the process of burning fish, the energy used and the change in energy from burning fish is chemical energy, which comes from the bonding of compounds in the fuel (firewood), which is used to produce heat energy. When burning fish, a change in chemical energy occurs, which comes from chemical bonds in the wood being burned into heat or heat energy. This heat then heats the fish, making it cooked and soft.

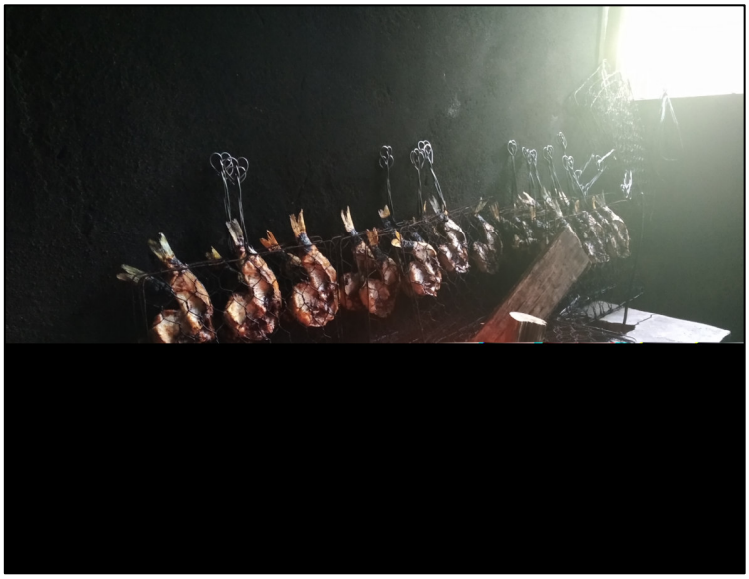

Figure 2. The process of grilling fish using firewood

The process of sprinkling hot water on ground chilies causes heat transfer through the hot water to the ground chilies, which causes the ground chilies to cook, producing a delicious taste.

Sale fish

The process of making sale fish starts from weeding, then removing the fish's entrails, splitting them but not cutting them in half, then continuing to smoke. Under the smoking area, wood has been prepared while maintaining the flame so that the smoked fish is perfectly dry. The fish is smoked using hot coals for approximately 24 hours. Every 4 hours the fish is turned over once so that the fish is cooked perfectly. The smoking process itself is a combination of heating and absorbing chemical substances that come from smoke, namely aldehyde compounds, phenols and organic acids which aim to kill bacteria, damage enzyme activity, reduce the water content of fish meat and absorb various chemical compounds. coming from smoke.

Sale fish has useful benefits for the body, including the content of vitamin B12. The benefits of vitamin B12 in smoked fish are almost the same as the benefits of vitamin B12 in other ingredients. Be it sale fish or fish benefits, all have sufficient protein content. Smoked fish is fish

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that is processed by smoking, so sale fish certainly has protein which is good for body health because smoked fish is also a type of fish that has many benefits. Apart from containing the benefits of protein, smoked fish also has the benefits of vitamin A, where the benefits of smoked fish with vitamin A are able to help treat eye diseases, because we know that the eyes really need vitamin A

Figure 3. Sale fish

Smoke contains various important chemical compounds, which determine the organoleptic properties and durability of smoking products. During the pyrolysis process in burning wood, various kinds of compounds will be formed which will accumulate in the smoke produced. Among them are compounds in the phenol group, carbonyls (especially ketones and aldehydes), various organic acids, alcohols, esters, furans, lactones, aliphatic hydrocarbons and polycyclic aromatic hydrocarbons. Phenol is a compound that plays a role in reducing product damage due to bacterial activity, has antioxidant properties and also functions as a distinctive flavor for smoking products.

Conclusion

The Angkola Batak tribe has a variety of culinary delights in their region, including sinyar-nyar fish and sale fish. The fish used in making this sinyar-nyar fish is goldfish obtained from Lake Siais, South Tapanuli, where the fresh goldfish are first cleaned and grilled until cooked using firewood. Then the crushed chilies and andaliman will be doused with hot water. Andaliman is the characteristic taste of this grilled nyar-nyar fish. The process of making sale fish starts from weeding, then removing the fish's entrails, splitting them but not cutting them in half, then continuing to smoke. Under the smoking area, wood has been prepared while maintaining the flame so that the smoked fish is perfectly dry. The fish is smoked using hot coals for approximately 24 hours. Every 4 hours the fish is turned over once so that the fish is cooked perfectly.

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